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Defective Product Detection Using Image Processing

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Abstract: ***Automation is very important factor in an industry which manufactures product in mass quantity. After manufacturing product; to make decision of rejecting or accepting is taken by measuring quality parameters. To measure quality parameters such as dimensions and features of manufactured product inspection is done manually in almost manufacturing industries. Manual assessment is time consuming, costly, sometimes inaccurate and manual assessment for complicated shapes is very difficult. To overcome these problems quality control and quality management for sensitive industrial product is feasible by use of image processing techniques. In this study use of 2D and 3D image processing is compared to detect edge defects. To extract features of manufactured product from image of product Principal Component Analysis (PCA) is used, defect detection in manufactured industrial products using edge detection methods gives the performance in acceptable range with them.***

Keywords: Image processing, Edge detection, Feature extraction, Quality control management.

1. Introduction

Image processing is one of the most increasing areas now-a-days. Image processing includes conversion of analog image into the digital image. Digital image is used to extract different features by performing some processes on images by use of computers and this process can be automatic. One of the most important and required operation on digital image is to recognize and categorize various kinds of defects. Thus to recognize the fault from given image, some methods are established and sited. Generally, the edges are demonstration of the discontinuities of image intensity function .There could be different reasons such as object geometry, lighting condition, type of material surface texture and their interaction, for discontinuities. Edge detection algorithm is basically a process of finding the defect in an image.

Automation plays important role in any mass production manufacturing industries. Rejecting or accepting final component before delivery to customer depends on its correctness of required dimensions and other features. Automatic sorting and packing is in existence for a number of years to assure quality but such dimensions and features of final manufactured product checked by hand in almost all manufacturing industries. Manual examination is costly, time consuming, sometimes incorrect and manual inspection for complicated shapes is very hard also method is destructive in some cases. Again human judgment is depends on prior knowledge and experience. If in some detection tasks there is a gradual change in structure or in some cases observer agree that the fault is there but observer cannot classify the structure. To overcome these problems quality control and management for sensitive product manufactured in industry is possible using 2D/3D image processing.

The edge detection process serves to make simpler the analysis of images by severely reducing the quantity of data to be process as well as at the same time preserve all useful structural information on object boundaries. There is surely a great deal of variety in the application of edge detection, but it is felt that a lot of applications share a common requirements. These set of requirements defer a conceptual edge detection dilemma, the resolution of which can be applied in any of the original crisis domains. [1]

In any manufacturing industries, first we have to identify requirement of customer then according to requirement plan for manufacturing of product as per customer's requirements then implement the plan followed by assessment. Quality checking is very important to withstand in market. To check quality of manufactured product it is necessary to identify fault in manufactured product to avoid defected product delivery to customer. Continuous inspection is required for quality enhancement. Based on previous attempt to achieve customers' requirement by redefine and planning same procedure can be repeated.

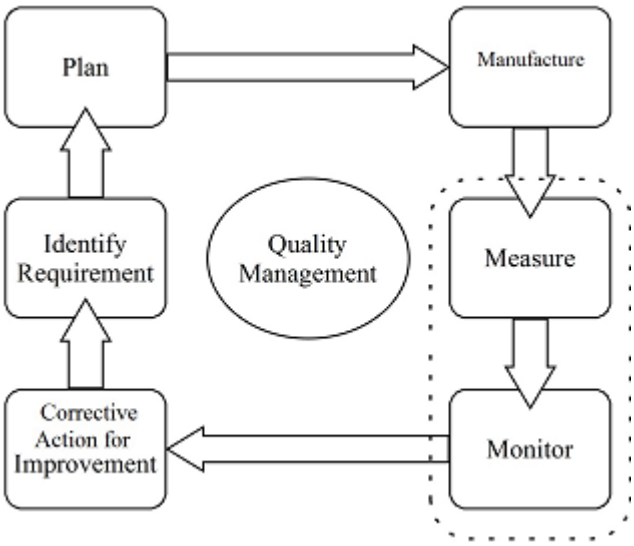

Figure 1: Explains about process of quality management

2. Related Work

Several researchers have paid attention to bridge defect inspection methods based on image processing. Canny [2] used computational approach to edge detection; he also used the criteria in optimization technique to obtain detectors for a number of common image features, including step edges; he found that there is some uncertainty principle between localization performance and detection.

A scheme which combined the ridge and edge detector outputs using feature synthesis was implemented, but the outcome were inconclusive. The Gaussian filter has number of features which accounts for its extensive use in several image processing applications. But, research demonstrates that edge detection techniques concerning this filter not give acceptable results. Linear methods presented in paper suffer from problems related with namely, Gaussian filtering, vanishing edges, edge displacement, and false edges.[3]

Suzana and Zeljko [4] used the edge detecting technique for defect detection in ceramic tile. The methods were the Sub-pixel corner locator method and the Canny edge detector method. Here firstly Canny edge detector method smoothers the image, then it locate its gradient, does threshold to eliminate insignificant edges and non-maxima suppression. In that way they find edges but also the defects on the images. The Canny edge detector method detected defect were scratches, cracks, spots, blobs and better results.

One of the mainly important applications is edge detection for image segmentation. Image segmentation is the process of partitioning a digital image into sets of pixels or multiple regions. Edge is a boundary with in two homogeneous regions. Edge detection refers to the process of locating and identifying sharp discontinuities in an image. The soft computing approaches consist of neural network based approach, Genetic algorithm based approach and fuzzy based approach. One of the most important applications of soft computing is the edge detection for image segmentation [4].

Herve and Lynne[5] used Principal Component Analysis (PCA); PCA is a multipurpose method that analyzes a data table in which are described by a number of inter-correlated quantitative dependent variables. Its main objective is to extract the significant information from the table and to represent it as a set of new orthogonal variables (Principal Components) and to show the pattern of similarity of the variables as points in maps. PCA generalized as correspondence analysis (CA) that handles by qualitative variables and as multiple factor analysis (MFA) that handles heterogeneous sets of variables. Mathematically, PCA depends on the Eigen decomposition of the singular value decomposition (SVD) of rectangular matrices and positive semi-definite matrices. Domingo Mery et al. [8] presented an X-ray machine vision technique to automatically identify fish bones. The steps of methodology for this work includes, image acquisition, preprocessing, feature extraction, segmentation, classification and post processing. This work yielded a detection performance of 100, 98.5 and 93.5 percentage for large, medium and small fish bones respectively. Murthad et al. [1] compared accuracy of using 2D edge defections detection is compared with 3D. Results showed that, 3D edge detections aid the decision making better than 2D edge detections algorithms in many cases. Here to extract features by using Principle Component Analysis (PCA).

Table 1: Summary of Literature Survey

Sr. No.	Author and Year	Work	Methods / Algorithm	Tools / Parameters
1	John Canny, 1986[2]	Computational approach to edge detection	Feature synthesis ; Gaussian Operator	Edge points and profile
2	Mitra Basu, 2002 [3]	Survey on Gaussian based edge detection method	Gaussian Filter	Edge detection
3	Suzana and Zeljko, 2006 [4]	Colour and surface efect detection in ceramic tiles	Canny edge detector and the sub-pixel corner locator method	Thresholds, minimum distance
4	D. Lu and Q. Weng, 2007[8]	Survey on techniques for improv-ing image classification performance	Remote sensing, classificat-io n process	Remote sensing and GIS
5	N. Senthilk-umaran and Rajesh, 2009 [9]	Survey on Edge Detection Techniques for Image Segmentat-ion	Soft computing approach based on the Fuzzy logic,GA and NN	Edge detection
6	Diwan P. Ariana and Renfu Lu, 2010 [10]	Evaluation of internal defect and surface color of whole pickles	Hyperspect-ral imaging	Reflectance and Transmitta-nce
7	H. Abdi and Willia-ms[5]	Analysis of data from table	Principal Component Analysis	Points in maps
8	D. Mery et al., 2011 [11]	Automated fish bone detection using X-ray	Image acquisition, preprocessin g, segmen-tati on.	X-ray

Gopinath al. [6] studied use of X-ray imaging technique for estimating the silk content and to determine the quality of cocoons and this approach found effective. Silk content estimation by using GRNN (General Regression Neural Network) method is effective. For the grading purposes SOM (Self Organizing Map) algorithm has been used, result shows that SOM algorithm can easily classify the cocoons and grade accordingly. If we use a new method for edge detection of images which contains upper constructor with LOG operator to compare with morphological operator, similar to the edge detection of brighter satellite images, it is found that the edge detection using Upper constructor with LOG operator provides better result for brighter satellite images [7].

3. Problem Statement

Quality Control for automated sensitive product manufacturing is one of the important aspects in almost all industries nowadays. Automated monitoring of the quality of the industrial products (Gear and some parts of the car engine) is nowadays done using sophisticated digital image processing techniques. Corner detection and sensitive parts features extraction is gaining more popularity in quality control activities. Presently 2D edge detection algorithms are available which can aid in this task; however they have their own limitations as they are not supportive, accurate and less effective for defect detection in industrial products. So in this context, 3D image processing can improve the accuracy of detecting the defects more significantly and can be more efficient. Hence, the essence of the problem lies in how to improve the quality of the industrial products using 2D and or 3D image processing techniques. This project proposes a novel 2D/3D image processing methodology for the quality control management for sensitive industrial products.

4. System Architecture

Figure 2 shows proposed architecture of system indicating sequence of operations to detect defect. Image will be extracted from vide using open CV. High-pass and low-pass filters will be applied on image to enhance quality of image. High-pass filters will highlight regions with high frequencies. Low-pass filters used for image smoothing and noise reduction their effect are averaging of the existing pixel with the values of its neighbors apparent as a ”blurring” of the output image (will allow to pass the low frequencies).

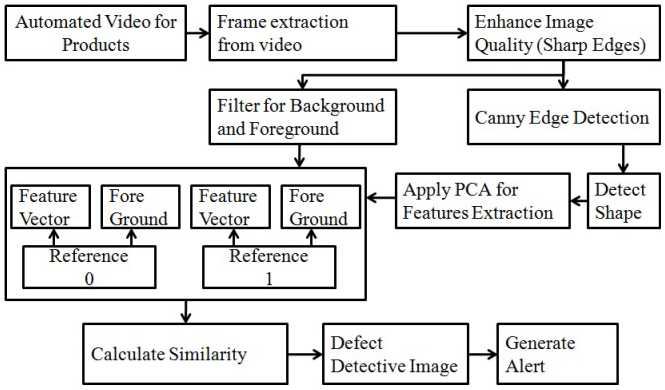

Figure 2: Proposed System Architecture

4.1 Algorithms

1. Foreground Extraction Steps
Input: RGB Image;
Output: Set of foreground pixels;
Steps:
1) Collect pixels from foreground model
2) Scan all pixels of image
3) Segment pixels with respect to foreground model, non-foreground model and un-categorized
4) Select segments with higher matching probability with foreground model
5) Replace segment with pixel values in new image

2. The Canny Edge Detection Steps
Input: RGB Image;
Output: Vector set edges;
Steps:
1) Smoothing: Blurring of the image to eliminate noise.
2) Finding gradients: The edges should be noticeable where the gradients of the image have huge magnitudes.
3) Non-maximum suppression: Only local maxima should be noticed as edges.
4) Double thresholding: Possible edges are determined by thresholding.
5) Edge tracking by hysteresis: Final edges are firmed by suppressing all edges that are not connected to a very certain (strong) edge.

PCA will be used to extract features of stored image and test image. The Euclidean distance applied between the features of standard images and the features of test image, to recognize the highest similarity image from the standard images to the test image, the Euclidean Distance Formula:

$$\text{Euclidean Distance}(\text{Img}_{ref}, \text{Img}_{test}) = \sqrt{\text{Abs}[\text{Img}_{ref}{}^{i} - \text{Img}_{test}{}^{i}]^2}$$

here;

Img_{ref} -features of Reference image

Img_{test} - features of Test image

Mismatching detection:
In this system described the formula which assets for matching and mismatching between the standard image and test image:

$$\text{Matching} = \frac{2|A \cap B|}{|A| + |B|}$$

$$\text{Mismatching} = 1 - \frac{2|A \cap B|}{|A| + |B|}$$

5. Results and Discussion

1) Type 1 defective:

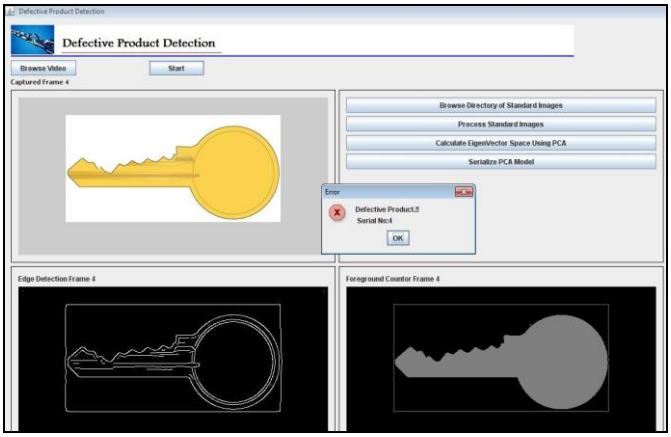

Figure 3: Type 1 defective

2) Type 2 defective

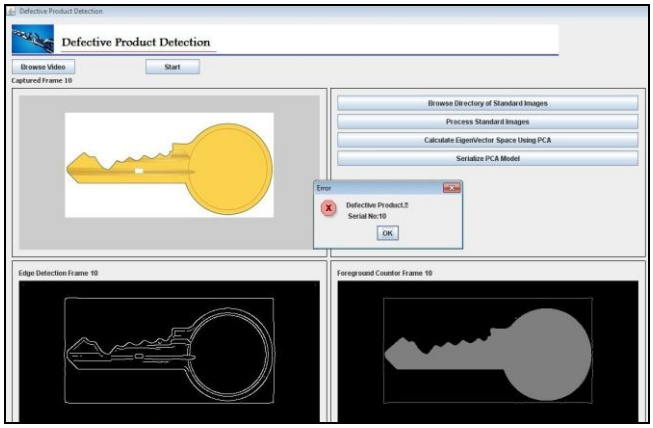

Figure 4: Type 2 defective

3) List of all defective products:

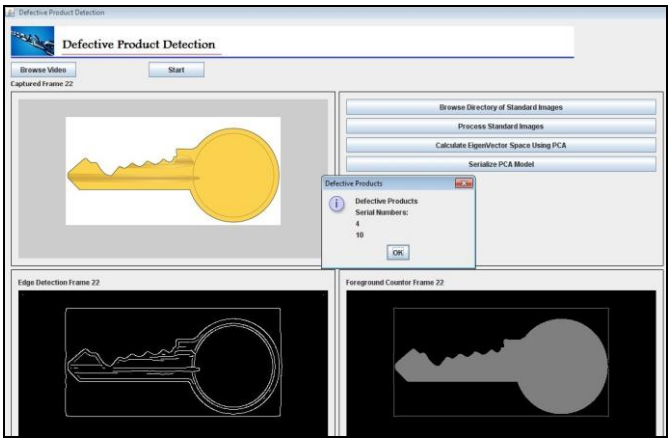

Figure 5: List of all defective products

Table 2: Result

Video Query	Frame	Defective Product	Correctly Detected	Accuracy
Key.avi	178	16	15	0.93
Sprocket.avi	120	42	37	0.88
Bolt.avi	272	13	11	0.84

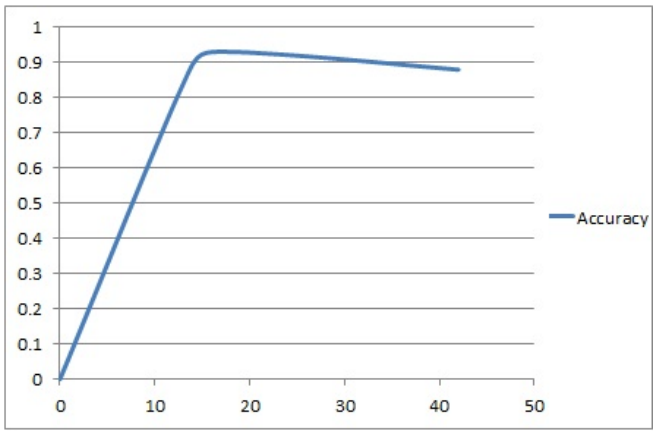

Figure 6: Precision and Recall

6. Conclusion

In this study, the image processing technique and application of image processing expertise for automatic inspection and defect detection is discussed. Although lot of research carried by different researcher doing research in images processing, there is scope to apply image processing techniques for quality control of industrial product. The image processing techniques are very powerful tool for automatic, fast and easier defect detection and quality control of various types of products. Algorithm is proposed for real time quality monitoring of manufactured product. This proposed system can replace manual inspection of industrial product. Result will indicate product is defective or non-defective. Using this automatic inspection system cost of inspection will be reduced also accuracy of inspection will increase.

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