Deformation Detection and Classification system for Car parts Products Using Image Processing Algorithms

Murthad AL-Yoonus¹, Aqeel Adel Yaseen¹, Mustafa Zuhaer Nayef Al-Dabagh²
¹Department of Technical Computer Engineering, Faculty of Engineering, AL-Kunooze University College, Basrah, Iraq.
²Department of Computer Science, Faculty of Science, Knowledge University Erbil, Iraq.
*Corresponding author: eng.murthad86@gmail.com

Abstract. Sensitive products deformation marking, and detection projects are becoming more interests in quality control management and widely used in automated industrial sensitive products production. The manual inspection by the workers for the sensitive industrial products is still taking long time and is not accurate and supportive enough for high quality control, automated deformations marking and detection by using image processing algorithms can increase highly the accuracy of detection for the defects in the products. In this paper, automated deformation detection and classification system based on some steps of image processing. Decision-making is made based on the percentage of deformations detection that aids for accept or reject the final car part product shape before deliver to users. In this work, the results were accurate to detecting the mismatching in industrial products for many cases. Automated deformations detections aid for better decision making to accepting or rejecting the products.

1. Introduction

Deformations detection in sensitive car parts products increases quality control management in production line, some of car parts are used in this work like (engine gasket, piston connector breaks parts) are defined as a reference standard images for this project. Monitoring the quality control of car parts manually is very difficult and slow. Inspection by worker for the sensitive parts of car is not accurate enough and taking more time, the manual inspection of deformations detection is more liable to mistakes [1,2]. The digital image processing techniques play very important role in many industrial applications.

There are many applications in medical and industrial field that are using digital image processing in machine vision to detecting defects in images by computers automatically. The mismatching detection and defects marking are the most important work on digital image for classification [3,4]. The inspection step is very necessary after manufacturing the products for each product. The most important step in quality control for every production operation is defects inspection and classification the products-based manufacturer criteria before the packaging and deliver to the user.

Recently, in industrial products manufacturing some works are used for detecting the deformation automatically by digital image processing algorithms, but still some of the existing works are just detecting the defects, in this work a robust method is proposed to be detecting and marking the deformations in sensitive car parts products. Deformation automated detection system based on machine vision is taking less time in inspection step and more accurate than the inspection by the workers. The first step of this work is acquisitioning the image of the products by fixed camera, and
the second step is using some algorithms for image enhancement and finally using some image processing algorithms to get final results for products classification.

In [5] showed a technique plays an important role in ceramic industries for detection the deformations and to manage the quality control of the ceramic production. Their classification technique system helps to detect and monitor the deformations within a very short time and also to classify the good quality tiles not mixed with the defected ceramic tiles. Some of related works used image-processing algorithms for products inspection to detect the defects. In [6] method proposed using genetic algorithm for automatic inspection of metallic surface defects, their work in three steps image acquisition, image processing and then decision-making, the results of the research showed high accurate detection for the cracks and holes in the metallic surfaces.

Quality control system of oil palm fruits inspection work developed a machine-vision system for estimation the free fatty acid, ripeness fraction and oil content, two methods used for their work first, multiple linear regression analysis. Second, a multilayer-perceptron artificial neural network analysis. The best results prediction accuracy of oil content, ripeness, and free fatty acid models were 96.4, 93.5, and 89.32%, respectively [7]. For misshaping detection that are using 2D/3D image processing algorithm in some industrial products and proof for the technique that using of 3D deformation detection is more accuracy than 2D deformation detection method, that improves the management of the quality control for factory production [8]. Detection system of blobs and cracks in surface of plain ceramic tile for maintaining the accuracy and time rate of ceramic production they used image enhancement and edge detection and then segmentation and the results high accuracy and short time of defects detection [9]. In [10] work showed use computer vision techniques for improve quality of inspection in food industry like cheese and meat, pizza, fish, and bread and also presented the most significant element of image processing technique that used in food industry. A real time automated system of defects detection for metal objects surface detection as pinhole, crack and dimensional deformation by using feature extraction and edge detection and classification by raspberry pi, the results showed using of automated inspection is better and faster than human inspection [11]. In [12] method presented visual inspection technique that detect the defects in the surface of ceramic bottle by using Niblack optimization, the method used image enhancement and defects segmentation and finally support vector machine as a classifier. In this work a by binary area filter is performed to extract all connected components (objects) from the binary image and the dice coefficient formula is applied to determine the percentage deformations [13,14].

The objectives of this project are to detect the deformation of car parts products and to mark the deformation on the image and then to classify the products based on factory criteria. This paper is organized: Section 2, shows the proposed technique of deformations detection classification system for car parts products. Section 3 presents the main results that got from some of car products. In the last section the conclusion of the work and recommended some enhancements in time processing and applications for future work.

2. Methodology
Deformations detection classification system for car parts products inspection is very important that needs very high accuracy system to detect the deformations and marking them and finding the percentage of these deformations for each product before deliver to users, to get high accurate results and accomplish the algorithm several steps are required. Figure 1 states the overall algorithm of this work.
2.1. Image pre-processing
Before the deformations detection an image pre-processing steps are applied on the image of the product which are, first image acquisition and then image enhancements.

2.1.1 Image acquisition.
To obtain digital image of product for testing from real source, a fixed camera is used for collecting the data image. In the acquisition step may some noises appear into the test image, for that reason a camera calibration is needed before acquisition.
2.1.2 Image enhancement

The purpose of image enhancement is to modify the images to be clearer for further analysis and processing. Industrial product images are acquired from fixed camera are not clear enough for processing. The image enhancement is performed in two steps. In this project, the acquired images are RGB, converted the image to grayscale image, then the gray level image enhanced by two filters to increase its accuracy.

To reduce the noise salt and pepper inside the digital images a median filter is applied and produce cleared and enhanced images, the median filter works by reordering the close pixels as middle value. The second filtering step is sharpening filter is applied on the image to increase the accuracy of the edges for the objects. Sharpening is a quick transition from white to black, the edges of objects looks sharper.

2.2. Deformation detection method

In this project, 12 different products are used to be as reference images, all the standard images are saves in one folder that linked to MATLAB software. Test image is compared with reference image for the same products, and then the deformations detection and marking algorithm has been applied. Figure 2 shows some of the different products used in this work.

![Figure 2](image)

**Figure 2.** References images of four different products (a) Break (b) Piston Connecting rod (c) Gasket (d) Motor-Gasket

2.2.1. Deformations detection and Marking.

Both standard image and test image after two steps of enhancement are converted to binary image and then use the (not function) to convert the ones pixels to zeros and also convert the zeros pixels to ones. The test image is compared with reference image of the same product, the resulted image from comparison is filtered by binary area filter to extract all connected components (objects) from the binary image, where the area of the objects is in range, this filter removes objects that do not meet the criterion. The default connectivity is 8 pixels.

For the deformations marking, the function of overlay image is applied between the binary image with the deformation objects that obtained from the last step and the test image. The image with the binary objects is burnt to the original test image, and the green colour is used for marking.

2.2.2. Deformations Percentage Detection and Classification.

The dice coefficient formula is used on both binary image (standard image and test image) to determine the percentage deformations in the test image. The formula of the dice coefficient for matching and mismatching is shown below in (1) and (2).

\[
\text{A: Reference image, B: Test image.}
\]

\[
\text{Similarity} = \frac{2 | A \cap B |}{| A | + | B |} \times 100
\]  

(1)
Mismatching = 100 - \left( \frac{2 \times |A \cap B|}{|A| + |B|} \right) \times 100 \quad (2)

The deformation classification system is based on criteria from factory that for the industrial products. The threshold is set for the highly sensitive car products, if the deformations percentage is greater than 0.1%, the product is rejected otherwise the product is accepted.

3. Experimental Results
In the results section shows the results through all steps of processing that proposed for deformations detection and marking. Sensitive car parts products images like (gasket, break, piston connecting rod, and some highly sensitive parts of car) are taken from websites and these images considered as a reference images for this work. Both images (test image and reference image) went through several processing steps starting from image enhancement and ending with deformation marking. All these processing steps are performed by MATLAB. For image enhancement, a pre-processing filter are applied that help to reduce the noise from the test image of the car part product. The second step of pre-processing is sharpening filter that enhances the edge of the products.

There are more three processing steps after image enhancement, both images (standard and test image) are converted from gray level into binary image and then the test image is compared with the standard image by subtracting. The binary area filter is applied for the resulted image from comparison that used to detect the deformations objects within the range of this filter and removed the small objects area as shown in Figure 3.

The green color is used for deformations marking, and the marking was clear and the same size of deformation in the test image. The deformation marking is done by overlay function in MATLAB, that considers the binary image with deformation objects as a mask for the original test image.
Twelve different types of car part products have been tested by the proposed work and all the results are clear and accurate enough for deformations marking. The decision-making is made based on the percentage of deformation and the criteria of factory. The system of deformations detection is ready for any type of industrial products.

The percentage of deformation in the test image is computed by using DICE Coefficient between the reference image and the test image. The decision-making based on threshold for the highly sensitive products that used for this work. If the deformations percentage is more than 0.1% the product is rejected otherwise it is accepted.

Figure 3 and 4, demonstrate the results of some different car parts products that go through processing steps end with deformation marking and deformation percentage.
| Product type        | Test product | Deformation detection | Deformation marking | Defects percent |
|---------------------|--------------|------------------------|---------------------|-----------------|
| Break               | ![Break Image](image1) | ![Break Detection](image2) | ![Break Marking](image3) | 0.40            |
| Piston Connect-Rod  | ![Piston Image](image4) | ![Piston Detection](image5) | ![Piston Marking](image6) | 1.8             |
| Gasket              | ![Gasket Image](image7) | ![Gasket Detection](image8) | ![Gasket Marking](image9) | 0.80            |
| Motor Gasket        | ![Motor Image](image10) | ![Motor Detection](image11) | ![Motor Marking](image12) | 6.8             |
| Gasket              | ![Gasket Image](image13) | ![Gasket Detection](image14) | ![Gasket Marking](image15) | 1.03            |

**Figure 3.** Main results of the proposed method
4. Conclusion

The proposed methodology is organized in some processing steps for both standard and test images and end with classification products-based factory criteria. The main results of deformations detection were accurate and clear enough for marking and classification, the main results of mismatching percentage are (0.4, 1.8, 0.8 and 1.03) of break, Piston connecting rod, gasket and gasket2, respectively. As a conclusion, the proposed deformation detection in car parts products shows the best results for deformations marking and classification. The future works will be using the project with hundred different industrial products and each group of products with different criteria for classification. Use of features extraction to detect high similarity product and then apply deformations detection with the test image. As well as, it is suggested to reduce the computational time of processing by using parallel programming.

References

[1] Cubero, Sergio, Nuria Aleixos, Enrique Moltó, Juan Gómez-Sanchis, and Jose Blasco. 2011 Advances in machine vision applications for automatic inspection and quality evaluation of fruits and vegetables. *Food and bioprocess technology*, 4 (4), 487-504.

[2] Pu, Yuan-Yuan, Yao-Ze Feng, and Da-Wen Sun. 2015 Recent progress of hyperspectral imaging on quality and safety inspection of fruits and vegetables: a review. *Comprehensive Reviews in Food Science and Food Safety* 14(2), 176-188.

[3] Hua, Guoliang, Weipeng Huang, and Hong Liu. 2018 Accurate image registration method for PCB defects detection. *The Journal of Engineering*, 16, 1662-1667.
A. A. Yassin, H. Jin, A. Ibrahim and D. Zou, 2012. Anonymous Password Authentication Scheme by Using Digital Signature and Fingerprint in Cloud Computing. In proceeding of IEEE International Conference on Cloud and Green Computing, 282-289.

Elbehiery, H., A. Hefnawy, and M. Elewa. 2005 Surface defects detection for ceramic tiles using image processing and morphological techniques. World Academy of Science, Engineering and Technology, 5.

Zheng, Hong, Ling Xue Kong, and Saeid Nahavandi. 2002. Automatic inspection of metallic surface defects using genetic algorithms. Journal of materials processing technology, 125, 427-433.

Makky, Muhammad, Peeyush Soni, and Vilas M. Salokhe. 2014 Automatic non-destructive quality inspection system for oil palm fruits. International Agrophysics, 28(3), 319-329.

Murthad Al-Yoonus, M. F. L. Abdullah, Mohammed Saeed Jawad, and Fares Al-Shargie. 2014 Enhance quality control management for sensitive industrial products using 2D/3D image processing algorithms. In Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS), IEEE. 126-131.

Meena, Yadraj, and Ajay Mittal. 2013 Blobs and Cracks Detection on Plain Ceramic Tile Surface. International Journal of Advanced Research in Computer Science and Software Engineering 3(7).

Brosnan, Tadhg, and Da-Wen Sun. 2004 Improving quality inspection of food products by computer vision—a review. Journal of food engineering, 61(1), 3-16.

Lohade, Dhanshree M., and P. B. Chopade. 2016 Real Time Metal Inspection for Surface and Dimensional Defect Detection Using Image Processing Techniques. 3rd International Conference on Electrical, Electronics, Engineering Trends, Communication, Optimization and Sciences (EEECOS).

LI, Li-yuan, Xue-wu ZHANG, Wen-tao LI, Xiao-qi SHAO, Yan XIANG, and Jin-bao SHENG. 2017 Visual Inspection Method of Ceramic Bottle Surface Defects Based on Niblack Optimization. DEStech Transactions on Computer Science and Engineering cmee.

Pratt, William K. 1991 Digital Image Processing. John Wiley & Sons, Inc. 634.

Cheetham, Alan H., and Joseph E. Hazel. 1969 Binary (presence-absence) similarity coefficients Journal of Paleontology. 1130-1136.