# Automatic Defect Detection: A Special Case using Titanium Coated Surfaces

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***Abstract:*** **The defects on coins and dies are one of the most important defects of titanium coated surfaces. To eliminate unqualified coins and dies reliability, this work has developed a defects-inspected system based on digital image process technology. In the proposed system contrast adjustment techniques are used for enhancing the digital images. By this, the rate of false detection can be reduced.**

***Index Terms — Titanium coated surfaces, Otsu's method, Contrast Adjustment, Image Processing, Defect Detection.***

## I. INTRODUCTION

At present, coins and dies can be made up of titanium coated surfaces. Fault may occur at any stage of this manufacturing process, and these faults are something that certain collectors look for. Coin errors that occur on the die are generally more fascinating than errors made at the time of the strike. Strike errors are generally unique, whereas all coins struck with an error die will have the same aspect. This makes them more easily collectible.

Titanium coated surface is a surface with uniform color and it contain tiny defects such as very small cracks, which cannot be seen by the naked eye or optical microscopy. Coins and dies are the examples of titanium coated surfaces. In the proposed system contrast adjustment techniques are used for enhancing the digital images. By this, the rate of false detection can be reduced. Lighting and shadow effects were found to influence the accuracy of defect detection. The effect of shadows in the lower region of the samples can be identified by the median based thresholding method.

In this paper, image preprocessing is included in the image acquisition state and is used to improve the quality of images. In image acquisition, a portion of the image (titanium coated surface) is cropped and then adjusts the contrast of the cropped region. Images are corrupted by different types of noises such as Rician noise. It is very important to have well quality of images for definite observations for the given application. Gaussian smoothing is used to remove noises while confining as much as possible the important signal features.

This system for defect detection on titanium coated surfaces with contrast adjustment consists of several steps. First of all image of a titanium coated surface is acquired and cropped for selecting a portion of the image, and then enhances the image using suitable contrast adjustment technique. Binarize the image using Otsu's thresholding method or median based Otsu's thresholding method. Binarization will represent the coated surface to 0 (black) using the image filling algorithm and the defect will be highlighted by representing it to 1 (white). The filling algorithm determines the area connected to a given node in a multi- dimensional array. It is used in the bucket fill tool to fill connected, similarly- colored areas with a different color.

Make gray scale of the selected portion before edge detection. Uniform color is one of the properties of titanium coated surfaces. If any microscopic defect is present on the surface, it flood fills the complete image. Therefore canny edge detection algorithm is suitable for detecting edges and avoiding the un wanted noises. Select the primary color and detect the defect that occurs in the image. In the defect detection stage, first calculate the centroid of the defects, which indicates the position of the defect.

Next stage is, to calculate the surface area of defects with respect to the coated sample surface area. At last, the percentage of the defect calculated to determine the extent of defects detectable using the proposed methods. Also, the proposed methods were able to correctly detect the highest number of predetermined defects in different sets of image resolution.

## II. IMAGE ACQUISITION AND CONTRAST ADJUSTMENT

Image preprocessing [1] is incorporated into the image acquisition state. Images are corrupted by different types of noises like Rician noise etc. It is very important to possess good quality of images (surface images for titanium coatings) for accurate observations for the given application.

Ti coated surface has one of the feature such as uniform color on the entire region. Therefore Ti coatings are used in case of coins, dies, surgical instruments etc. They also provide long life by preventing the corrosion. Image with different resolution can be used for studying the features. First of all select the image and choose a portion of the image.


Fig. 1. Image of Titanium coated Surface

In the case of images of titanium coated surfaces, the rate of false detection increases due to the lightening and shadow effect. To reduce this rate of false detection [2], enhance the contrast of the image using the contrast extension [3] method.

## III. THRESHOLDING AND IMAGE FILLING

For defect Detection suitable thresholding technique [4] is utilized to obtain the corresponding binary image. The defect would be displayed in a different color (white) as compared to the rest of the coating (black). The optimum threshold value t* can be calculated either by Otsu's method [5] or by Median Based Otsu's method. The threshold t divides the image into two classes. 'C0' is the foreground class and 'C1' background class.
By Otsu's method

$$t* = \underset{1 \leq t \leq L}{\operatorname{argmin}} \sigma_W^2 = \underset{1 \leq t \leq L}{\operatorname{argmin}} \{\omega_0(t)\sigma_0^2 + \omega_1(t)\sigma_1^2\}. \quad (1)$$

By Median Based Otsu's method

$$t* = \underset{1 \leq t \leq L}{\operatorname{argmin}} \{\omega_0 \, \text{MAD}_0 \, (t) + \omega_1 \, \text{MAD}_1 \, (t)\} \quad (2)$$

Where w0 and w1 are the occurrence of probabilities of the foreground and background class, MAD refers the mean absolute deviations. If the levels are >t*, then the pixels are converted to 1 and converted to zero if levels are <= t*. Binarization represents coated surface to black. Then fill the image using suitable algorithm.

## IV. EDGE DETECTION

Make gray scale [6] of the selected portion before edge detection. Gray image is also known as an intensity, or gray level image.

The equation used for the conversion of gray scale image [1] is as follows;

grayScale = (R * .3) + (G * .59) + (B * .11) (3)

Gray levels mean the interval number of quantization in gray scale image processing.

The desire of edge Detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for added image processing. Edges are important local changes of intensity in an image. Edges typically occur on the boundary between two different regions in an image of that scene and to extract important features from the edges of an image. These features are used by higher – level computer vision algorithms.

After the edge detection state, the entire image is filled. The filling algorithm is used to find connected components with eight connected neighborhood.

## V. DEFECT DETECTION

First step is to filter the defect and analyze it. For that area of each defect is calculated. The area of one defect is asserted as 'Ak', where k = 1, 2, 3, 4… N, and N is the number defects detected based on the number of connected components. For each Ak, the area is calculated based on the number of pixels m for the corresponding area of defects Ak, such that Ak = a1 + a2 + a3 + ………. + am.

The centroid of the defect can be calculated using

$$C_{kx} = \frac{\sum c_{mx} a_m}{A_k}, \quad C_{ky} = \frac{\sum c_{my} a_m}{A_k} \quad (4)$$

where Ckx is the x-coordinate and Cky is the y-coordinate. The centroid value indicates the position of the defects. In this study, mark the location of defects in the original image by red crosses having the size of 3 pixels.

Second step is to calculate the surface area to determine the area of defects with respect to the coated sample surface area. The surface area of the coated samples was computed based on the filled binary gradient mask, as it represents the surface of the sample given.

In third step, the percentage of the affected area is calculated. The total defected surface area AD is represented by the summation of surface areas of Ak for N number of detected defects, denoted as;

AD = A1 + A2 + ……..+ AN = $\sum_{k=1}^{n}$ Ak (5)

Thus the percentage of defect Pd for each image is

Pd = ($\sum_{k=1}^{n}$ Ak / A*T*) x 100% (6)

## VI. CONCLUSION

Automatic surface defect detection system can bring manufacturers a number of significant benefits, particularly when used in-line. They can help to cut down levels of scrap and improve quality, leading to both cost savings and increasing a company's competitiveness.

In this paper, a method based on image processing was presented to detect the defects on the Titanium coated surfaces and can reduce the rate of false detection using contrast adjustment.

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