

Eminent Inspection of Chip Resistor using Combination of Optimal Edge Detection and Location M Estimation Method

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ABSTRACT: Accuracy and precision are most important parameters regarding quality inspection of physical dimensions of any electronics object or component or any device in an Electronic Industry. It directly affects many or almost all electronic circuit performances, and also it plays a vital role. In this paper we have tried to measure the mechanical or physical dimensions of chip resistor with the combination of optimal edge detection method and robust estimation method to achieve high precision with accuracy. Different optimal edge detection algorithms such as Marr-Hildreth algorithm LoG, Canny algorithm and Shen Castan algorithm with location M estimator (Robust M estimation) are used to inspect mechanical dimensions (notch) of chip resistors.

KEYWORDS: Quality Measurement, Location M estimation, Optimal Edge detection, ISEF (Shen Castan algorithm), Canny Edge Detector, LoG.

I. INTRODUCTION

In the Practical field or in an Electronics Industry, measurement of mechanical dimension of any object/device is very important task before production. To do such a cumbersome task, machine vision system can be employed to measure mechanical dimensions of any object/device. In an Electronic industry, it is very difficult to measure dimensions of SMD electronic component. In this paper, we have tried to measure mechanical dimension specifically notch of chip resistor using machine vision (location M estimation & optimal edge detection) with high accuracy and precision. To achieve highest accuracy in measurement of notch of chip resistor, we have employed combination of Optimal edge detection and Location M estimator method. Most commonly optimal edge detection methods are LoG algorithm, Canny Edge detector, ISEF (Shen–Castan’s) algorithms. In this paper we have used all above three with Location M Estimator (Robust M) to find dimensions of notch. In Section-II we discuss the Related Work. In Section-III we discuss about different Optimal edge detection techniques. In Section-IV we discuss about Location M Estimation. In Section-V we presented Experimental method used for inspection of chip resistor using machine vision and Results are discussed in Section-VI. Section-VII concludes the paper.

II. RELATED WORK

In [1] Chintan K Modi et al., has proposed to use Robust M estimation method for surface roughness measurement. Location M Estimator in [2] J D Chauhan et.al has used it to find the optimal distance in the bottle filing problem. They had discussed that by using location M estimator one can easily avoid the error caused by the outliers. In [2] J D Chauhan et al. has proposed to use optimal edge detection techniques with robust M estimator to find distance from reference line in capacitor. In [3] Kunal Pithadiya et al. proposed to use optimal edge detection techniques like ISEF [5] and Canny edge detection [4] instead of template based edge detectors. The algorithm proposed in [2] computes average distance from a reference line using robust M estimation which is susceptible to outliers. After inspired from [2] we have tried to use methods like median, and robust M estimation with any optimal edge detection techniques like LoG, Canny edge detection and ISEF edge detection to inspect the notch of chip resistor.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, Februray 2016

In [7] Phillip G. Creter et al. discussed about highly reliable testing of dimensions of component and also dependency of it on electrical parameters. In [9] B. Wunderle et al. has discussed about formation and dimension of chip capacitor which affects the behaviour of capacitor. From that we are inspired to work on notch measurement of chip resistor with high accuracy and precision.

III. OPTIMAL EDGE DETECTION TECHNIQUES

The main disadvantage of template based edge detectors is their dependence on the size of the object and inaccurate. So we have worked with Optimal Edge detection techniques. There are basically three types of optimal edge detection methods used 1. LoG Algorithm 2. Canny Algorithm and 3. ISEF algorithm.

A. LoG algorithm [3][5][8]

LoG is outlined in Table-I for which, Locality is not especially good, and the edges are not always thin. Still, this edge detector is much better than the previous one in case of low signal to noise ratio. Malfunctioning at corners, curves and where the gray level intensity function varies, not finding the orientation of edge because of using the Laplacian filter. As per Table I initially, input image is convolved with Gaussian function. Then compute the laplacian of the resulted image. So it is called Laplacian of Gaussian image.

TABLE I
LOG ALGORITHM

| No. | STEPS |
|-----|---|
| 1 | Convolve the image I with a two dimensional Gaussian function. |
| 2 | Compute the Laplacian of the convolved image; call this L. |
| 3 | Edges pixels are those for which there is a zero crossing in L. |

B. Canny algorithm [4][5][8]

Canny specified three issues, that an edge detector must address viz., Error rate, localization and response [4]. Canny algorithm convolves the image with the derivative of a Gaussian, the canny implementation uses a wrap-around scheme when performing the convolution, and the areas near the boundary of the image are occupied with black pixels, although sometimes with what appears to be noise. As per Table II, first the image is convolved with Gaussian mask. Then calculate first derivative in x and y directions with mask already created and get Ix' and Iy'. Lastly find magnitude using equation given. This will result the edge detected image.

TABLE II
CANNY ALGORITHM

| No. | STEPS |
|-----|--|
| 1 | Read the image I. |
| 2 | Convolve a 1D Gaussian mask with I. |
| 3 | Create a 1D mask for the first derivative of the Gaussian in the x and y directions. |
| 4 | Convolve I with G along the rows to obtain Ix, and down the columns to obtain Iy. |
| 5 | Convolve Ix with Gx to have Ix', and Iy with Gy to have Iy'. |
| 6 | Find the magnitude of the result at each pixel (x, y). |

$$M(x, y) = \sqrt{I'_{x(x,y)}^2 + I'_{y(x,y)}^2}$$

C. ISEF Algorithm [3][5][6][8]

Shen and Castan [8] maintains, that it's filter gives better signal to noise ratios than Canny's filter, and provides better localization. This could be because the implementation of Canny's algorithm approximates his optimal filter by the derivative of a Gaussian, whereas Shen and Castan uses the optimal filter directly, or could be due to a

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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difference in this way the different optimality criteria are reflected in reality. Shen-Castan's Infinite symmetric exponential filter based edge detector is an optimal edge detector which gives optimal filtered image. First the whole image will be filtered by the recursive ISEF filter in X direction and in Y direction, which can be implement by using equations as written below. Then the Laplacian image can be approximated by subtracting the filtered image from the original image.

At the location of an edge pixel there will be zero crossing in the second derivative of the filtered image. The first derivative of the image function should have an extreme at the position corresponding to the edge in image and so the second derivative should be zero at the same position. And for thinning purpose apply non maxima suppression as it is used in canny for false zero crossing. The gradient at the edge pixel is either a maximum or a minimum. If the second derivative changes sign from positive to negative this is called positive zero crossing and if it changes from negative to positive it is called negative zero crossing. We will allow positive zero crossing to have positive gradient and negative zero crossing to have negative gradient, all other zero crossing we assumed to be false and are not considered to an edge. Now gradient applied image has been thinned, and ready for the thresholding. The simple thresholding can have only one cutoff but Shen-Castan suggests to use Hysteresis thresholding. Spurious response to the single edge caused by noise usually creates a streaking problem that is very common in edge detection. Recursion in x direction:

$$y_1[i, j] = \frac{(1-b)}{(1+b)} I[i, j] + b y_1[i, j-1], \quad (1)$$

$$j = 1 \dots N, i = 1 \dots M$$

$$y_2[i, j] = b \frac{(1-b)}{(1+b)} I[i, j] + b y_1[i, j+1] \quad (2)$$

$$j = N \dots 1, i = 1 \dots M$$

$$r[i, j] = y_1[i, j] + y_2[i, j+1] \quad (3)$$

Recursion in y direction:

$$y_1[i, j] = \frac{(1-b)}{(1+b)} I[i, j] + b y_1[i-1, j], \quad (4)$$

$$i = 1 \dots M, j = 1 \dots N$$

$$y_2[i, j] = b \frac{(1-b)}{(1+b)} I[i, j] + b y_1[i+1, j], \quad (5)$$

$$i = M \dots 1, j = 1 \dots N$$

$$y[i, j] = y_1[i, j] + y_2[i+1, j] \quad (6)$$

b=Thinning Factor (0<b<1)

The output of an edge detector is usually thresholded, to decide which edges are significant and streaking means the breaking up of the edge contour caused by the operator fluctuating above and below the threshold. Streaking can be eliminated by thresholding with Hysteresis. Individual weak responses usually correspond to noise, but if these points are connected to any of the pixels with strong responses, they are more likely to be actual edge in the image. Such connected pixels are treated as edge pixels if there response is above a low threshold. Finally thinning is applied to make edge of single pixel. The ISEF algorithm is given in Table III.

As per this Table III, apply Infinite Symmetric Exponential Filter in X and Y direction separately. Then apply binary laplacian tech and non-maximum suppression technique to remove false edges. Find gradient of resulted image to differentiate the image from the background. Then to get window thresholding, apply Hysteresis thresholding and thinning to get thin edges.

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TABLE III
ISEF ALGORITHM [5] [8]

| No | Steps |
|----|----------------------------------|
| 1 | Apply ISEF Filter in X direction |
| 2 | Apply ISEF Filter in Y direction |
| 3 | Apply Binary Laplacian Technique |
| 4 | Apply Non Maxima Suppression |
| 5 | Find the Gradient |
| 6 | Apply Hysteresis Thresholding |
| 7 | Thinning |

IV. LOCATION M ESTIMATION METHOD [1][2]

It is always normal practice to find average of data to get final result with average operator or we may use Median function to estimate final result. Fig-1 shows the data sample with outliers. Now, if we find average of data shown then result with outliers and without outliers will be different. So in some cases average operator will not be so useful to find result. There is one method called Location M estimation to find the result with some attractive below explained features.

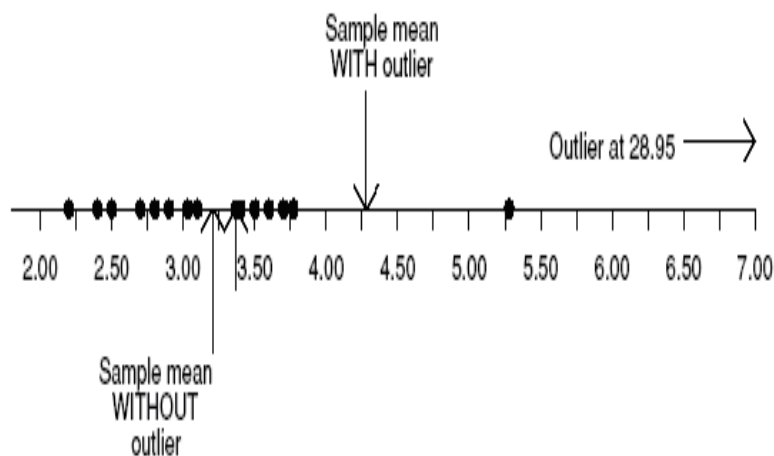


Fig. 1. Effect of a single outlier on average operator

For a dataset Y having n data points, the location model is given by $y = mx + c$ with x equal to zero. Fig.1 shows the effect of outlier with an average operator. This outlier will be eliminated by location M estimation. To find the location estimate \hat{y} , the least squares method minimizes the summed square of residuals given by

$$E = \sum_{i=1}^n e_i^2 = \sum_{i=1}^n (y_i - \hat{y}_i)^2 \quad (7)$$

The residual for the i^{th} data point e_i is defined as $e_i = y_i - \hat{y}_i$, where \hat{y}_i is predicted value. The solution of equation (7) is

$$c = (\sum y_i) / n \quad (8)$$

The problem of average operator of equation (8) is that it is not robust towards outliers [6]. The estimate may tend to give erroneous results because its objective function $E = \sum_{i=1}^n e_i^2$ increases indefinitely with the residuals e_i . Hence, extreme outliers with arbitrarily large residuals can have an infinitely large influence on resulting estimate. Robust M-

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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estimators attempt to limit the influence of outliers by replacing the square of the residuals with a less rapidly increasing loss function of the residuals e_i . Out of many loss functions, Tukey biweight objective function is especially resistant to observation on the extreme tails because the derivative function $\psi(.) = \rho' (.)$ for Tukey function redescends to zero.

The tuning constant k , is expressed as a multiple of scale of y_i , $k=CS$, where S is the measure of the scale of y_i . Since the standard deviation is more influenced by extreme observations we use the median absolute deviation (MAD), $S = \text{Median}|y_i - \hat{y}_i|$. To further normalize the median with respect to population we use $S = \text{MAD}/0.6745$. For Tukey biweight function $k=4.685*S$ produces 95% efficiency. Differentiating the objective function of equation (10) with respect to c and setting the partial derivatives equal to 0, will result into system of equation given by $\psi(.) = \rho' (.)$. Defining the weight function $w(e) = \psi(e)/e$ and solving the estimating equations is a weighted least-squares problem, minimizing $\sum w_i^2 e_i^2$. The weights depend upon the residuals and residuals depend upon estimated coefficients which again depend upon the weights. An iterative algorithm called as iteratively reweighted least squares, IRLS is required, which is outlined below [1].

1. Select initial estimates $c^{(0)}$, such as the least squares estimates.
2. At each iteration t , compute $e_i^{(t-1)}$ and weights $w_i^{(t-1)} = w[e_i^{(t-1)}]$ from previous iteration.
3. Solve for new weighted-least-squares estimate $c^{(t)}$. Steps 2. And 3., are repeated until the estimated coefficients converge.

The general M-estimator minimizes the following objective function

$$\rho_B(e) = \begin{cases} \frac{k}{6} \left\{ 1 - \left[1 - \left(\frac{e}{k} \right)^2 \right]^3 \right\} & \text{for } |e| \leq k \\ \frac{k}{6} & \text{for } |e| \geq k \end{cases} \quad (9)$$

$$\sum_{i=1}^n \rho_B(e_i) = \sum_{i=1}^n \rho_B(y_i - \hat{y}_i), \quad \hat{y}_i = c + e_i \quad (10)$$

V. EXPERIMENTAL METHOD

In this experiment method, as shown in Fig-2, we have divided the notch termination area of chip Register in three parts: A, B and C. Area A, B and C are shown in the Fig-3. The method, to find out the distances for area A, B and C is shown in Table IV respectively.

As per Table IV first get the image and apply different optimal edge detection method explain earlier. Then measure median distances for area A, B and C of notch in chip resistor for each edge detection method as shown in Fig.3. Then find Location M Estimation distances for all edge detection method listed above.

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TABLE IV[8]
Algorithm to find distances for Area A, B and C

| No. | Steps |
|-----|---|
| 1 | Acquire the image as shown in Fig-2. |
| 2 | Apply different optimal edge detection algorithm. |
| 3 | Measure different distances for Area A, B and C from the reference line for each method as shown in the Fig-3. |
| 4 | Median Distances for area A and B must be the same. For area C, distances will be little less than distances for area A as shown in Fig-3. |
| 5 | Find Location M estimator distances for Area A, B and C for each optimal edge detection method and compare it with median distances found for each edge detection method. |

Optimal edge detection methods like LoG, Canny and ISEF are used. The LoG, Canny and ISEF operated edge detected output of chip resistor sample image are shown in Fig-4, Fig-5 and Fig-6 respectively.

LoG and Canny optimal edge detection method uses Gaussian function to find or detect different edges of an image. Shen castan's ISEF is near optimal with exponential function, the optimality condition is checked and proved to be optimal one. Hence it is preferable to use most optimal edge detection methods to examine the physical dimensions of the chip resistor.



Fig. 2. Sample Image

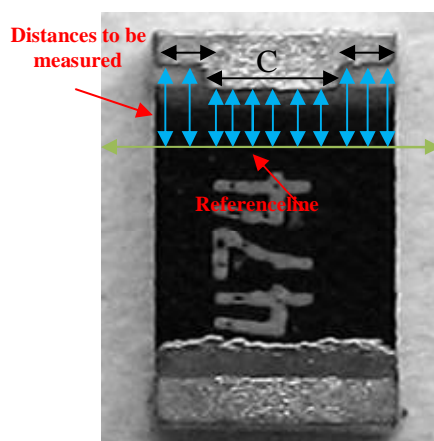


Fig. 3. Experimental Method

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VI. RESULT AND DISCUSSION

In this paper we have found the notch termination distances for Area A, B and C using optimal edge detection methods with Location M estimation methods shown in Table V.

TABLE V
Experimental result of distances for Area A, B and C

| Distance Operator | LoG | | | Canny | | | ISEF | | |
|---------------------|------|------|------|-------|------|------|------|------|------|
| | A | B | C | A | B | C | A | B | C |
| Median | 28.5 | 29.0 | 14.0 | 29.0 | 29.5 | 14.0 | 28.0 | 26.5 | 12.0 |
| Robust M Estimation | 28.4 | 28.5 | 13.5 | 29.0 | 29.3 | 13.5 | 28.0 | 27.2 | 12.3 |

After applying LoG (Threshold=0.015), Canny (threshold=0.7) and ISEF (with $b=0.77$, $HT=100$, $LT=46$ and $thinning=4$) edge detectors, the output images are shown in Fig-4 for LoG operated edge detected image, Fig-5 for Canny operated edge detected image and Fig-6 for ISEF operated edge detected image respectively. The notch termination distances for Area A, B and C are shown in the Table V using all three optimal edge detection methods with different distance operators (Median and Robust M estimation). The distances shown in terms of no. of pixels instead of mm for the accurate result.

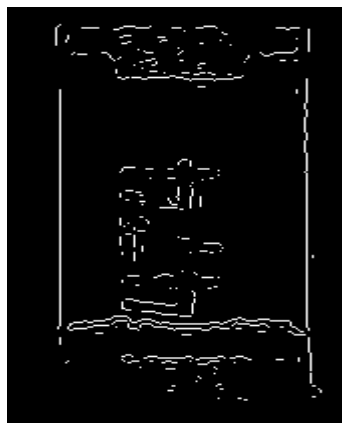


Fig-4. Edge Detected Image
LoG Operated

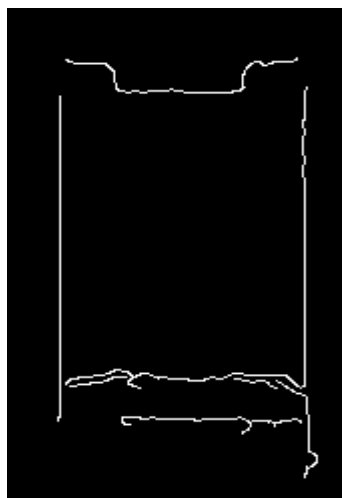


Fig. 5. Edge Detected Image
Canny Operated

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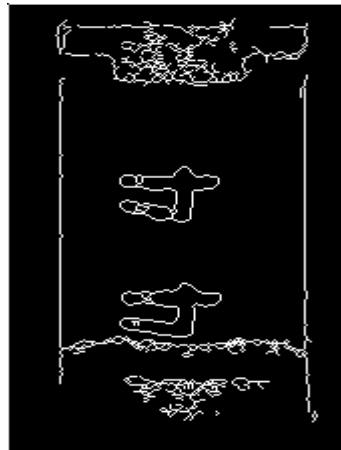


Fig. 6. Edge Detected Image
ISEF Operated

VII. CONCLUSION

In the result, we have compared the performance of median, Location M estimation with different edge detection techniques for the application of chip resistor's notch inspection using machine vision system. Median and Location M estimation with any optimal edge detection technique gives optimal solution for distance estimation. From the result it is been concluded that, if the Robust location M estimation is used with any type of optimal edge detector then the obtained results are very accurate and highly precise and can give better decision about the notch termination in chip resistor inspection.

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