

## DEVELOPMENT OF HULL CRACK DETECTION USING IMAGE PROCESSING FOR HULL INSPECTION

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### ABSTRACT

The crack on the ship hull might cause huge harm and disaster towards a vessel. The crack might affect the safety and performance of the vessels. Nowadays, hull inspection is being done by a human being. This may cause some errors and miss inspection area of the hull. With the application of the technology wave, the usage of computer vision technology is needed in this field. This research aims to develop a crack detection system by using image processing for ship deficiency using MATLAB software. Then, a suitable image processing method is being analyzed to enhance the quality of the image for different situations. In this research, the Sobel edge detection operator is being used as the most accurate and precise operator among the three classic operators. It is the most convenient and less time-consuming operator that can be used and has been used in the civil field.

**Keywords:** *Hull crack; Image processing; MATLAB software; Sobel edge detection*

### 1 INTRODUCTION

Hull inspection is one of the crucial methods in ship inspection to keep good ship maintenance. In-hull inspection, cracks, corrosion, leaks, ruptures, and other defects can be detected. Unchecked hull defects may lead to bigger risks and harms that could finally result in huge losses. One of the problems in hull inspection that lead to unchecked defects in the hull is the use of visual inspection in hull inspection. In manual inspection, the visuals of cracks are being sketched manually. Due to this, it will result in a human error which is in irregularities of the defects. However, by using image processing, it will generate the analytical and accurate results of the cracks and their depth automatically and this statement was supported by Arun Mohan et al, 2017. Another research by Carlos Fernández-Isla et al, 2013 in which stated that manual inspection will lead to excessive degradation of image and results in inaccurate defects segmentation thus this research will explain and proves the problem stated by the previous researcher. This research is aimed to develop the crack detection system by using the image processing for ship deficiency by using MATLAB software and to analyze the suitable image processing method to enhance the quality of the picture for different situations. To achieve the research objectives, research questions issued are how to develop the crack detection system by using the image processing for ship deficiency by using MATLAB software and how to analyze the suitable image processing method to enhance the quality of the picture for different situations.

## 2. SIGNIFICANT OF RESEARCH

This research will give a significant from three-point of view which is for society, computer modeling, and hull inspection. The benefit gained for society is as for the owner or the company of the ship, the hull condition can be maintained and prolonged in a good shape with defect-free and cracks-free. Nowadays, implementations of technology are being applied worldwide in all industries. So, as for the computer modeling aspect, computer modeling will have an advance and up-to-date technology regarding enhancing the quality of low resolutions images by using the software. Last but not least, in the view of hull inspection, this research, it can make the hull inspection obtain accurate and specified results in highlighting the crack.

## 3. LITERATURE REVIEW

Image processing is a set of algorithms that can perform a few operations. The operations related include image processing, visualization, and analysis. This toolbox is also widely being used for image segmentation, image enhancement, and 3D image processing. The image processing toolbox is very suitable for any range of applications. was widely being used in various industries including medicine, biomechanics, and engineering. This is due to a good results analysis from computational image results from a good quality of input images (Joao Manuel R. S. Tavares, 2010)

Edge detection is one of the techniques that is used and included in the image processing method. One of the edge detections that are usually being used is Sobel Edge Detection. stated in his study that the difference between Sobel edge detection and other detection is Sobel was known for measuring 3x3 pixels by using two kernels in order to define the gradient.

The Sobel operator is used to calculate the gradient by using the following algorithm:

$$G = \sqrt{S_x^2 + S_y^2} \quad (1)$$

As information,

G: Sobel gradient operator value

$S_x$  : Horizontal Sobel gradient

$S_y$ : Vertical Sobel gradient

The pixels around the pixels (x,y) is being arranged in the following arrangement in figure 1.

$a_0$	$a_1$	$a_2$
$a_7$	$(x, y)$	$a_3$
$a_6$	$a_5$	$a_4$

Figure 1. The arrangement of pixels

From the arrangement, the formula to calculate the value of x-gradient and y-gradient was formed.

$$S_x = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6) \quad (2)$$

Which  $c$  is known as a constant of 2. The matrix formed will be as figure 2.

$$S_x = \begin{array}{|c|c|c|} \hline -1 & 0 & 1 \\ \hline -2 & 0 & 2 \\ \hline -1 & 0 & 1 \\ \hline \end{array}$$

Figure 2. The matrix formed by the x-gradient's values

As for the value of the y-gradient, it will be formed a slightly different arrangement of numbers.

$$S_y = (a_0 + ca_1 + a_2) - (a_6 + ca_5 + a_4) \quad (3)$$

Which  $c$  is a constant of 2. The matrix formed will be as figure 3.

$$S_y = \begin{array}{|c|c|c|} \hline 1 & 2 & 1 \\ \hline 0 & 0 & 0 \\ \hline -1 & -2 & -1 \\ \hline \end{array}$$

Figure 3. The matrix formed by the y-gradient's values

In order to calculate the magnitude gradient, the calculated value of x-gradient and y-gradient is being used.

$$|S| = \sqrt{S_x^2 + S_y^2} \quad (4)$$

The edge appears to differentiate the object's boundaries. This edge detection can enhance the existence of the object's boundary lines in an image (Darma Setiawan Putra, 2019).

#### **4. PROBLEM STATEMENT**

Hull inspection is one of the crucial methods in ship inspection in order to keep good ship maintenance. In-hull inspection, cracks, corrosion, leaks, ruptures, and other defects can be detected. An unchecked hull defect may lead to bigger risks and harms that could finally result in huge losses.

One of the problems in hull inspection that lead to unchecked defects in the hull is the use of visual inspection in hull inspection. In manual inspection, the visuals of cracks are being sketched manually. Due to this, it will result in a human error which is in irregularities of the defects. However, by using image processing, it will generate the analytical and accurate results of the cracks and their depth automatically. This statement will be supported by a paper entitled Crack Detection using Image Processing: A critical review and analysis by Arun Mohan and Sumathi Poobal in 2017. Another research by Carlos Fernández-Isla, Pedro J. Navarro, and Pedro María Alcover (2013) also stated that manual inspection will lead to excessive degradation of image and results in inaccurate defects segmentation.

From the statement stated above, a solution and alternative should be taken to avoid all the unnecessary problems. Thus, this research is to highlights the development of crack detection by using image processing that can be applied in hull inspection. Image processing can enhance the image quality including concentrating on non-uniform lighting and color correction. This process can improve the inspection method with a shorter duration.

#### **5. SIGNIFICANCE OF RESEARCH**

This research will give brilliant significance from a three-point of view which is for society, computer modeling, and for hull inspection. The benefit gained for society is as for the owner or the company of the ship, the hull condition can be maintained and prolonged in a good shape with defect-free and cracks-free. Nowadays, implementations of technology are being applied worldwide in all industries. So, as for the computer modeling aspect, computer modeling will have an advance and up-to-date technology regarding enhancing the quality of low resolutions images by using the software. Last but not least, in the view of hull inspection, this research, it can make the hull inspection obtain accurate and specified results in highlighting the crack.

#### **6. RESEARCH METHODOLOGY**

The image collected will undergo three processing stages which are pre-processing, processing, and post-processing. The Sobel's Edge Detection system is being used in the processing stage. Most of the data used are collected from UniKL MIMET.

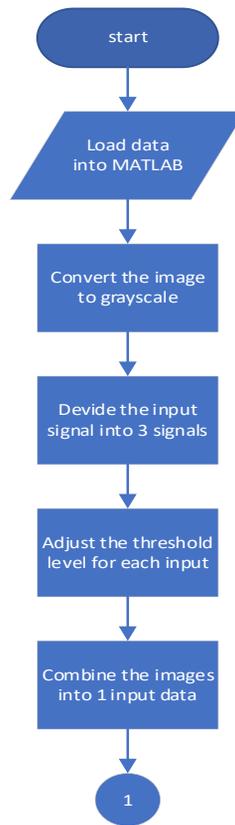


Figure 4. The flowchart of frameworks of pre-processing in image processing

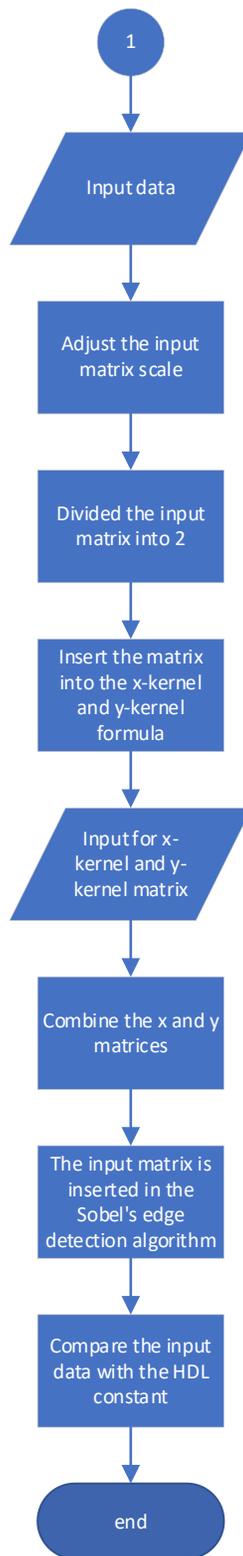


Figure 5. The flowchart of the processing method which used Sobel Edge Detection as a process

## 7. RESULTS AND DISCUSSION

The data were collected from different places includes UNIKL MIMET's slipway and Pantai Puteri which is located in Malacca. The data is also from various types of hulls which are normally being used in the shipping industry. The hull snapped includes aluminum, fiber, and wood. This was to show that the designated SIMULINK block was applicable for all types of material. In addition, the data was also being collected by using a smartphone's camera with 12MP resolution.

The results of the processing were tabulated as a table of comparison. The results of processing by using Sobel edge detection are compared to the results of processing by using Roberts edge detection and Prewitt edge detection. This is because these three methods of edge detection are known as the classic operator before another edge detection was developed.

Table 1. the table shows the comparison of pros and cons of Sobel edge detection, Roberts edge detection, and Prewitt's edge detection

<b>SOBEL EDGE DETECTION</b>	<b>ROBERTS EDGE DETECTION</b>	<b>PREWITT EDGE DETECTOR</b>
A better version of Roberts edge detection	Works most likely as Sobel edge detection	The operator needs to identify the magnitude of the image.
The operator can detect the edges at the highest gradient point of the image.	The operator can detect a normal crack in the image with a high spatial frequency.	It is time-consuming
It is very detailed and can detect the tiny edge.	Can detect tiny crack	If it cannot estimate the magnitude, it cannot detect the edges.
It can work well with the presence of noise	The cons are it cannot works well in the presence of noise.	The cons are it cannot works well in the presence of noise.

The image with bright colors such as yellow and white will give an error in the Roberts edge detection operator. The combination of too much contrast color also will result in a disturbance in Roberts and Prewitt's operator. The disturbance will produce a few extra unnecessary lines in the processing result because the operator cannot determine which is the real crack and which is the line that causes by the disturbance. However, with the use of Sobel's operator, it can neutralize the noise and abandon the disturbance which will lead to more accurate results compared to Roberts and Prewitt. At a first glance, it might seem as same but if the results are thorough analysis, the extra lines and holes can be seen as different.



Figure 6 Original image

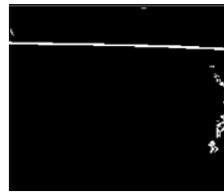


Figure 7 Sobel Edge Detection

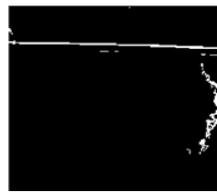


Figure 8 Roberts Edge Detection



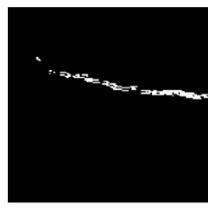
Figure 9 Prewitt's Edge Detection

The comparison shows that the Roberts operator produced a result with a few extra lines compared to the Sobel operator and Prewitt operator. This is because the contrast in the color of the image produces some disturbance during the processing and leads to additional lines in the result. As for Prewitt, the difference can be seen in the yellow circle. The disturbance makes the operator confuse whether the hole really exists or vice versa. Hence, it results in tiny unconnected holes compared to the result by the Sobel operator.

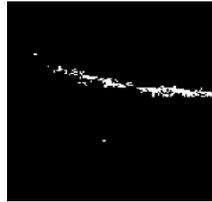
As for these results, the comparison showed a very clear difference between the Sobel operator's result and the Roberts operator's result. The additional presence of marks and confusion in the thickness of the crack occurred because of the disturbance that affect the processing stage. The disturbance also resulted in confusion for the Prewitt operator in order to determine the continuous crack that exists on the hull. Therefore, the Sobel operator was known as the better version of the Roberts operator and convenience operator to be used in the image processing method.



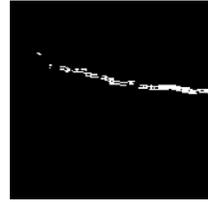
*Figure 10  
Original image*



*Figure 11 Sobel  
Edge Detection*



*Figure 12 Roberts  
Edge Detection*



*Figure 13  
Prewitt Edge  
Detection*

## 8. CONCLUSION AND RECOMMENDATION

The research is being done in order to applicate new technologies, which is image processing in the hull inspection field. This is to make the hull inspection more precise and easier. The output of the system is also analytically easy to read and view. With this system, the blurred image, unclear image, or noise image can be enhanced and being processed in order to detect the crack on the ship's hull. Besides, this system also can be used without being an expert in the related field and it is low cost. In a nutshell, with this system, common and minor errors can be avoided.

There are a few recommendations that need to be done to fabricate the effective model and upgrade the system.

- i. For the recommendation, the project process needs to be reconstructed or added some new features or filters in order to obtain a more accurate result. By adding more filters in the process of the system will affect the accuracy of the crack detection.
- ii. Next, adding some additional features such as detecting the width of the cracks also will help in improving the system. This will make the system more valuable to be in the market and the maritime sector. With the discovery, the system will give new experience to the market which provides less time and expenses in making a vessel or re-fitting the vessel.

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