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Evaluation of Edge Detection Filters Applied to Corroded Steel Sheets

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Abstract:- The detection of corrosion in steel sheets is an important task for the shipbuilding industry and is usually carried out through visual inspection. Some articles have analyzed this issue using digital image processing and have shown promising results. One of the stages of digital image processing involves the detection of edges, which can provide important and useful information about the corrosion state of the plate and characterizes the object's limits, being important for segmentation, registration or identification of objects. Many works have evaluated the images processed by the detection of edges with linear filters, some of them using the quality of the visual aspect of the processed image as a parameter, while others usually use entropy and PSNR. In this article, the objective of the work is to evaluate the performance of these filters and the behavior of entropy and PSNR applied to images of corroded plates. A corrosive solution was prepared in which six steel sheets were numbered and partially immersed in this solution. On each day, the plates were removed from the solution and photographed, the image being analyzed in the code. As a result, we conclude that entropy allows us to identify the best filter to analyze corrosion, while PSNR does not allow us to distinguish the difference in performance between the filters. Of the seven filters analyzed, the Canny filter showed the highest entropy value. On the other hand, the entropy values for each filter, apparently, do not depend on the corrosion time.

Keywords:- *Component; Formatting; Style; Styling; Insert (Key Words).*

I. INTRODUCTION

Ship operations in harsh climatic operations can deteriorate the hull structure which suffers corrosion-erosion effects as well corrosion-cavitation process. Corrosion detection and its analysis can be carried out by visual inspections, chemical or physical process [1]. However, this operation usually requires removing the ship from the water and is a complex operation involving costs and risks.

Then, some tasks, especially those that endanger human life, are done using remotely controlled robotic vehicles, most of which have a camera. As the image is a source of information, it can be processed digitally, providing useful information for the user, being sometimes called machine vision system.

Digital image can be manipulated in order to provide useful information [2–5]. For the extraction of information, one of the steps involves the detection of edges of the image.

Edge characterizes the object boundaries and are important for segmentation, registration, or identification of objects[6]. For an image, edge is abrupt change gray-level change of pixels locations. The goal of edge detection algorithms is to find the most relevant edges in an image and use this information in later stages such as counting, measuring, identifying characteristics, and classification[3].

Edge detection methods generally depend on the first or second derivative along the intensity profile. The first derivative, gradient based, identifies the border and the second derivative, Gaussian based, determines whether a pixel is on the dark side or on the bright side of an edge [3] and usually involves convolution of the image with an operator, also called as masks.

There are several edge detections filters like Roberts, Prewitt, Sobel, Canny, Lindeberg, Laplacian of Gaussian (LoG), and Kirsch. However, the performance of these filters for non-trivial images can be low. Details of these filters can be found in [2–4, 7] as well as a review of some papers about the subject [8].

Maan and Singh have analyzed the performance of these filters for some types of images. They compared the performance of the filters with binary images (black and white) and identified that the edges produced by the Roberts, Sobel, Prewitt filters deviated slightly from the original image while the edges generated by the other filters are almost the same [9].

Similarly, Owotogbe, Ibiyemi, and Adu analyzed the behavior of filters in binary images and noted that Sobel, Prewitt, Robert filters are inaccurate while the Canny filter had better accuracy compared to other filters. The Sobel filter is suitable for finding smooth curved edges, the Roberts and Prewitt filters are simple and suitable for detecting edges in the horizontal and vertical directions. The Canny filter can detect false zero-crossing while the LoG filter can detect the edges in several directions, being sensitive to noise [10].

Another paper discussed the behavior of these filters in grayscale images in terms of the entropy of the image, which is a measure of the amount of information contained in the image, related to the texture of the processed image, from Peak Signal- to-Noise Ratio - PSNR and Mean-squared error - MSE, which measure the metric quality of the image in terms of noise [11]. The results showed that the Canny Filter reaches the highest entropy value and the lowest PSNR values, showing that it is a suitable filter for the detection of edges.

Image quality affects the values of these parameters. The quality of the image is fundamental for edge detection and some factors can interfere [10-11]:

- Illumination.
- Shadow.
- Noise.
- Surface discontinuities.
- Depth discontinuities.
- Color and Texture discontinuities.
- Specularities.
- Reflectance.
- Light dispersion.

Image processing with edge detection can be applied in several areas [2, 3], specially doing inspections in steel plates. Corrosion can affect the ship integrity and image processing is a valuable tool that can help detect corrosion or deformation in the structure of steel sheets.

Corrosion detection and analysis can be done through chemical or physical based approach or image processing-based approach. This approach is cost-effective and provides quick and reasonably accurate results [1].

Some papers deal with corrosion analysis using digital image processing getting good results. One approach is to use texture analysis. A system was designed to detect corrosion in some objects [13]. Basically, the method has the following steps:

- gray conversion.
- Texture filter.
- Edge detection.
- Enhanced image.

Another approach is to develop a code using artificial learning machines [1]. In this case, the code has the following steps:

- Acquire image.
- Image pre-processing.
- Image segmentation.
- Feature extraction.
- Machine learning.
- Image classification and analysis.

In another paper, a system was designed to assess the structural state of submerged steel sheets, detecting corrosion or bulging [13, 14]. The underwater images are essentially characterized by their poor visibility because the light is attenuated in the water and the suspended particles causes reflections noise. The light attenuation process is caused by absorption and scattering. In that paper, linear filtering technique was employed to identify edges in a sample of steel sheets. A code with Sobel adjusted by two parameters showed as a promising tool to highlights points of corrosion or deformation being an important support tool for the inspection of the ship's structure conditions.

The purpose of this work is to evaluate the filters behavior in images of corroded plates identifying the performance of these filters in terms of the entropy and the PSNR. Such results will be useful when the mentioned interferences will be analyzed. Therefore, it is hoped that with this project companies of construction and maintenance of vessels can use this tool in the naval field.

II. METHODOLOGY

A solution with water, salt (1 kg) and vinegar (200 ml) was prepared in which six steel sheets were numbered and partially immersed in this solution. On each day, the plates were immersed in the solution and, at the end of the day, a photograph was obtained and analyzed in the code. As the result, a processed image was obtained showing the corrosion parts. The process was done for 12 days.

III. CODE

The code was written using the free Octave app. The code for the analysis of the images contains the following structure:

- Image acquisition.
- Gray conversion.
- Edge detection.
- Entropy and PSNR.

The filters Roberts, Prewitt, Sobel, Canny, Kirsch, Lindeberg, and Laplacian of Gaussian (LoG) were used for the edge detection.

IV. RESULTS

By 12 days, pictures were taken, and the images were processed. A sample of these pictures is shown. Fig 1 shows the sample of pieces with corrosion and Fig. 2 to 8 show the image processed.

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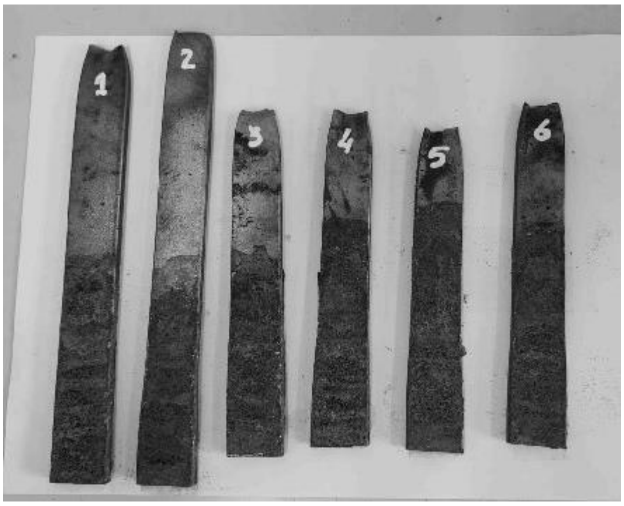

Fig 1:- Original image.

The pieces were submersed partially in the solution to check the performance of these filters to detect the corroded part.

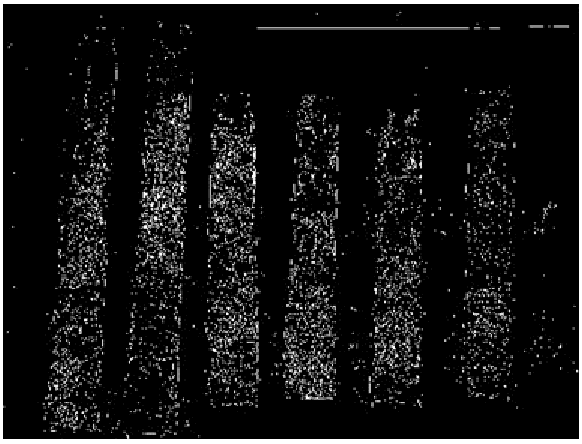
Fig 2:- Roberts filter applicated.

As can be noted, the Roberts filter detects the entire piece but cannot to distinguish the corroded part.

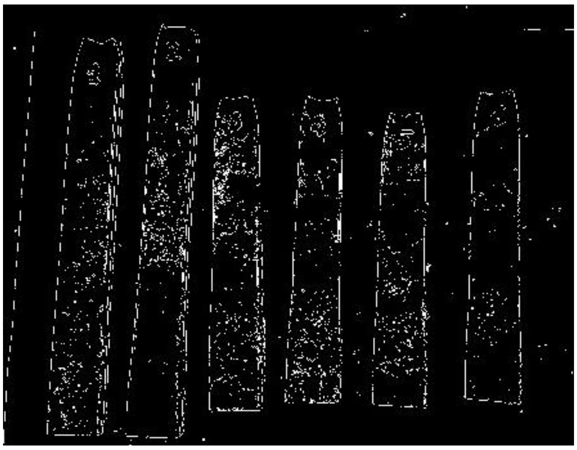
Fig 3:- Prewitt filter applicated.

Visually, the Prewitt filter has a better performance than Roberts filter and as pointed out by some authors is suitable to detect horizontal and vertical lines [10]. However, it is necessary to improve the code to detect the corroded part.

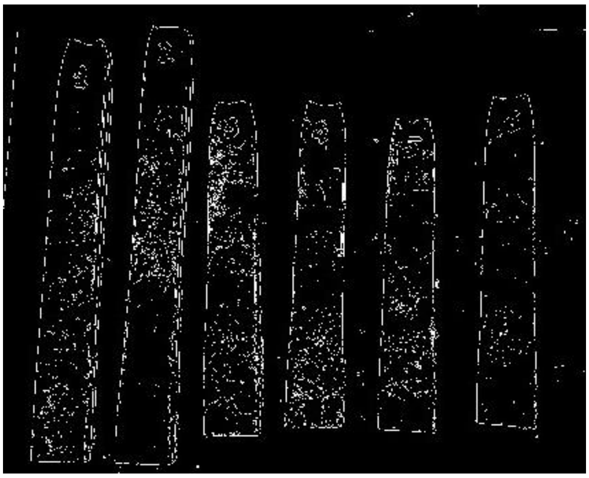
Fig 4:- Sobel filter applicated.

The Sobel filter apparently has the same behavior as the Prewitt filter and needs to improve the code only using the edge step to detect the corroded part.

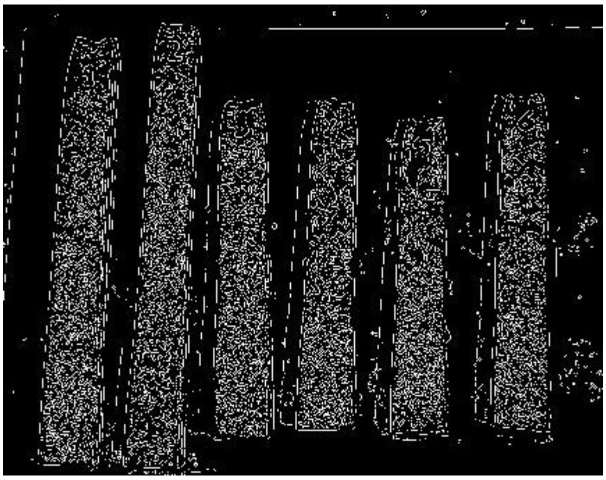
Fig 5:- Canny filter applicated.

The Canny filter detects the entire piece but cannot detect the corroded part.

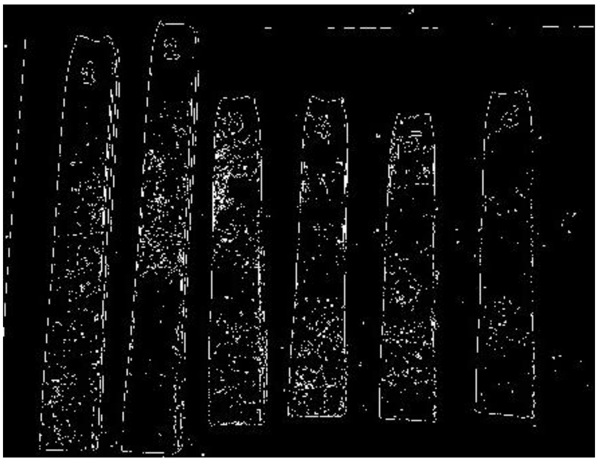
Fig 6:- Kirsch filter applicated.

The Kirsch filter detects the border of the pieces but cannot detect the corroded parts.

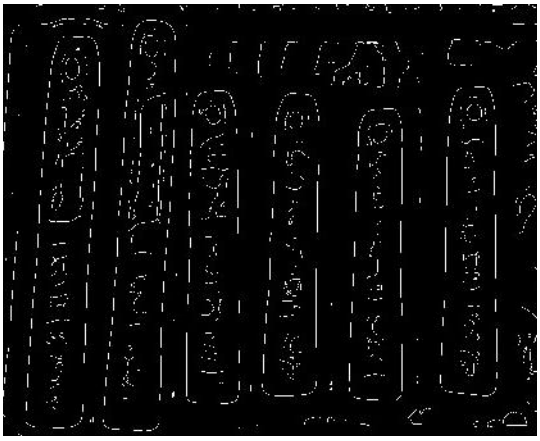

Fig 7:- Lindeberg filter applicated.

Visually, the Lindeberg filter is not suitable to use to detect edges or even the corroded part.

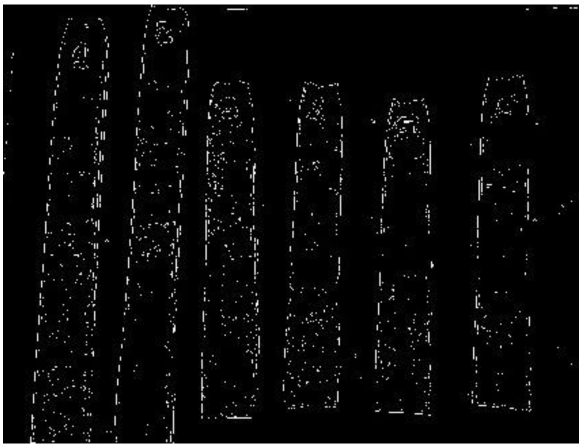

Fig 8:- LoG filter applicated.

The LoG filter look like better than Lindeberg. We highlight here that the processed images were obtained with the edge command, providing a binary image.

Fig 9 shows the entropy for the processed image over the days.

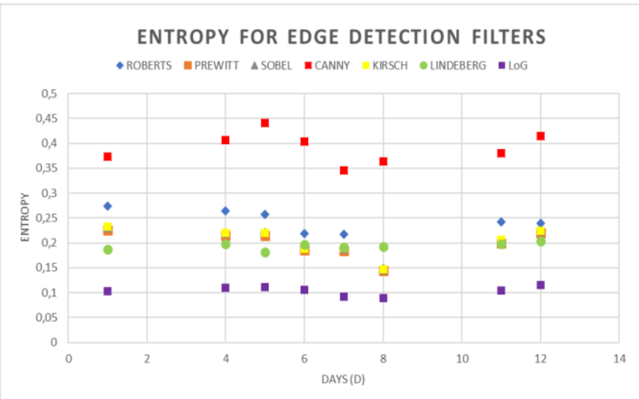

Fig 9:- Entropy for edge detection filters.

The first point to observe is that the LoG filter has the lowest entropy while the Canny filter has the highest value, while the others have similar values, which slightly contrasts with visual perception.

The other point to note is that the entropy value of the processed image, for each filter used, varies very little over the days. Thus, entropy is an important parameter that can be used for digital processing of images that involve the detection of elements in the original image. Considering the mean value for the entropies over the day, Fig 10 shows that the values obtained from the entropy of the processed image show that the standard deviation of the processed image is small for the Lindeberg and LoG filters. Roberts, Prewitt, Sobel, Kirsch, and Lindeberg filters show close values.

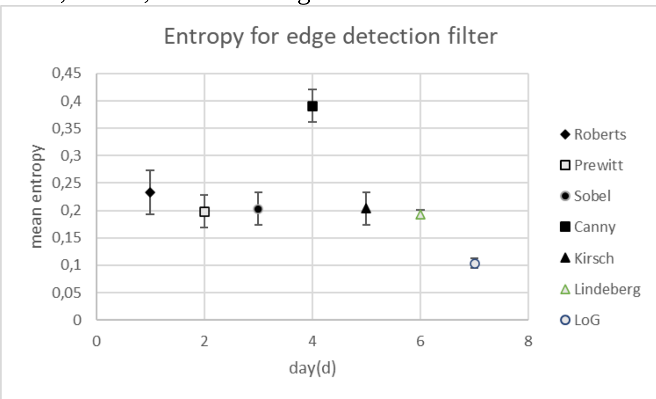

Fig 10:- Mean value for the entropy of the processed image.

Some authors have used PSNR to assess image quality. Fig 11 shows the PSNR value and we observe that there is no variation in the PSNR values for the filters over the days. However, we realized that the PSNR values for each filter are very close so that the PSNR indicator does not provide information for choosing the most suitable filter for the analysis of corrosion in steel plates.

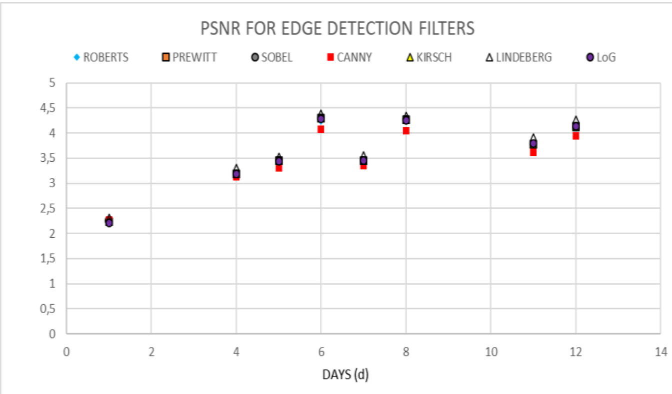

Fig 11:- PSNR values of the processed image.

Thus, by comparing the two parameters, entropy provides clues on the choice of the best filter to detect corrosion.

V. CONCLUSION

In this article, a brief summary of the works that use digital image processing was made in order to analyze corrosion problems using edge detection.

The objective of this work is to evaluate the behavior of filters in images of corroded plates, identifying the performance of these filters in terms of entropy and PSNR.

A code in Octave was prepared to analyze the images.

As noted, entropy allows to identify the performance of each filter used while the PSNR does not allow to distinguish the difference in performance between the filters.

Of the seven filters analyzed, the Canny filter proved to be more appropriate for the detection of corrosion and its value can be used to improve the quality of the processed image.

Thus, it is intended to analyze and develop a code using entropy and the Canny filter to detect the corroded region and check the possibility that the code indicates the level of corrosion of the plate.

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