IPEN XV COPINAVAL Meeting
Montevideo - Uruguay
11 - 14 Nov. 1997

INSTITUTO PANAMERICANO DE INGENIERIA

IMAGE PROCESSING TECHNIQUES APPLICATIONS TO SHIP PAINTING ANALYSIS.

Odair Caltabeloti
Technological Research Institute(IPT), São Paulo, BRAZIL

Oyan Kai
São Paulo University, São Paulo, BRAZIL

Toshi-ichi Tachibana
São Paulo University, São Paulo, BRAZIL
tatibana@usp.br

Kanji Yamagishi
JICA
Japan International Cooperation Agency

Takeshi Shinoda
Kyushu University - JAPAN

ABSTRACT

This paper presents a procedure for a evaluation of painted steel plates after some period of rusting. Japanese and Brazilian paints exposed to a marine environment during one year were used, and many grades of rusting for each type of paint were obtained and compared with Japanese results. To measure the level of corrosion, a method of image processing was applied.

All the results, as well as the methodology for this evaluation, can be used as parameters for maintenance of ship hull and offshore structure surfaces and also improve marine preservation including the environmental problems generated due to use of paints that can have systems in Harmony with marine behavior, in consequence the human being benefits.

1. INTRODUCTION

In the field of corrosion and protection of metals with coatings, the usual methods of evaluation of rusted or corroded surfaces exposed to atmospheric environment have been during years the visual inspection of the pin hole detection on the painted surface.

The recent improvement of image processing with personal computers has made possible apply the mathematical morphology and the image processing techniques for many field of technology, such as the evaluation of micro-structures with the automatic counting of grains (metallography) or the quantitative analysis of biological material.

On the other hand, the application of an image processing method could be helpful in order to reduce subjective criteria for evaluation, and it could lead to a more quantitative analysis, in such a way that it would help to improve the quality of protection materials for marine use.

2. MATHEMATICAL MORPHOLOGY AND IMAGE PROCESSING

A digital image is a function that maps a gray scale or a colored image into a matrix were each point (x,y) is represented by the matrix element, called *pixel*. Each pixel's intensity is represented by 1, 2, 4, 8 or more bits of memory. One bit is sufficient for simple "black & white" operation, and for 256 different colors or tons of gray 8 bits are necessary.

The usual color-component encoding schemes involve the use of a *color map*. The values stored are treated as addresses into a table of color defined by their red, green and blue components.

There are many techniques recently developed to process images, which are classified according to the *type of problem* they are able to solve. Techniques like *digitization, enhancement, restoration* and *segmentation* of images can be achieved by morphological approaches. By applying morphological operators, objects with special features can be identified and extracted. Finally, a combination of statistical computations and syntactic analysis can offer some insights about the information stored in the original image.

The most useful image processing technique for evaluation of the level of corrosion seems to be the separation of the preserved surface and the rusted surface in different layers and the evaluation for each layer. This technique is

00001

usually called thresholding and if the image parameters (brightness, hue, saturation) exceeds a threshold, a pre-defined or an average color is displayed. In this sense, it becomes possible to reduce the number of colors from 256(for images of 8 bits) or even 16 million (for full color images) to a limited number of mean colors between thresholds.

3. Methods of Evaluation

For the evaluation of the level of corrosion in a rusted surface at first it becomes necessary to stablish values used as a reference for comparison. ASTM - Annual book 1996 - standard - section b Paints - Related Coatings and Aromatics - vol. 06-02 Paint - Products and Applications; Protective Coating, Standard test Method for evaluating. Degree of Rusting or painted steel surface - D610-95 and guidance for classification on coating condition - UR Z 10.1 and Z 10.2 of Nippon Kaiji Kyokai - Japanese Ship Classification Society. Figure 1(a) shows the typical rust (1) and to (2) grade no. 4 (10% rust), For this and all the other standard surface grades the image scanning was performed and the results obtained showed a good relationship between the percentage of rust that is written in this standard and the ratio of corroded area and total surface area.

At first, the image was separated in three thresholds, the first corresponding to the painted surface (white), the second to the softly rusted or contaminated surfaces (light gray), and the third to the rust spots or corroded parts of the surface (black).

The evaluation procedure considered the heavier corrosion level and the surface was separated in two levels, as shown in figure 1(c).

After that, the image was saved as a bitmaps file and converted to an encapsulated post script(eps) file. The vectored form of an eps image is more practical not only for printing output, but also for further calculation. A software was developed for counting and evaluation on the surface condition. An preliminary computer program was developed only for testing the methodology and the main parameters for output were:

1. the number of elements;
2. the average rust size;
3. the number of elements of rust with each size.

For item 3, the total number of elements was separated in groups according to the area of each element when compared to the total area of study, and a statistical curve was done. The curve uniformity was verified as the number of elements was increased.

4. Experimental Data

The evaluation was performed with 75 pieces, painted with the Brazilian and Japanese ship's hull paints and exposed to marine environment. Each test piece measured 200 x 300 mm and was divided in four parts, each one with a different number of paint layers, and different thickness as a consequence.

After periods of rusting of 12 and 18 months respectively, each test piece was photographed and the images were scanned. The evaluation method explained in the item 2 was therefore performed. As the paints used were basically epoxy with high performance, the most deteriored part of the test pieces corresponded to the primer coating only, and it's expected to obtain a better evaluation during the next years. The comparison with data supplied by the Japanese paints manufacturer will be done later.

Up to the present moment, the present moment, the comparison of the results obtained with many samples was helpful to check up the image processing evaluation system and the comparative study of Brazilian and Japanese research shall be the next step of the present study.

5. Conclusions

Concerning the evaluation procedure, the most important advantages observed are the following:

- of course, there is still the influence of the person who is on charge of the evaluation, because this person will decide what is the most important level of rusting, when separating the image thresholds. However, it was verified in this study that the percentage of rusting according to ASTM D610-95, is very close the contamination (light gray and gray layers in Fig 1(b)). Therefore, it's always necessary to use

00002

IPEN XV COPINAVAL Meeting
Montevideo - Uruguay
11 - 14 Nov. 1997

these or similar "calibration" values, to avoid as much as possible subjective criteria, for example, ASTM and NK-Nippon Kaiji Kyokai International reference.

- the curve obtained by the separation of elements according to the rusted area is the most useful information. It was verified that when the rust grade increases, not only the peak of this curve becomes higher, but it can also move to the right, when the area of each rust spot increases with time. For some paints, the first behavior described above (nucleation) and growing from the first spots) was verified while for others, the second one was verified.
- the improvement of an evaluation criteria for paints could be helpful in order to reduce the problem of corrosion, therefore contributing for the development of materials acting in harmony with the marine environment, and the more optimized systems.

6. Aknolwlodgements

The authors wish to acknowledge the contributions of all researchers of IPT and professors of São Paulo University (USP) and also all the colleges for the encouragement and support for this research.

The thanks are also extended to the Brazilian Development Organizations, CNPq - "Conselho Nacional de Desenvolvimento Científico e Tecnológico" and FAPESP - "Fundação de Amparo à Pesquisa do Estado de São Paulo" for supporting some items of this research. Special Thanks to the Japan International Cooperation Agency (JICA), for all the equipment and materials that were supplied for this work.

7. References

[1] AMERICAN SOCIETY FOR TESTING AND MATERIALS, 1996. Standard test method for evaluating degree of rusting of painted steel surfaces. In: ANNUAL BOOKS OF THE ASTM STANDARDS. Philadelphia, 1996, V.06.01, p. 13-15.

[2] MARTINS, F.P.R. 1993 Morphological Image Processing System . MsC Dissertation, Wales University Press.128p.

[3] RIMMER, S., 1993 Bit-mapped Graphics. 2 ed. New York, WINDCREST/McGraw-Hill Inc. 484p.

[4] STEEL STRUCTURES PAINTING CONCIL, 1989. Steel structures manual. Pittsburgh. V.1.

[5] NIPPON KAIJI KYOKAI, 1993 Guidance for classification TZ2932 P0020 Tokyo p 80-95.

[6] Oyan Kai, 1997. APLICAÇÃO DAS TÉCNICAS DE PROCESSAMENTO DE IMAGENS NA ANÁLISE DA CORROSÃO DE CASCO PINTADO DE NAVIO, MsC. Dissertation, University of São Paulo, 104p.

00003

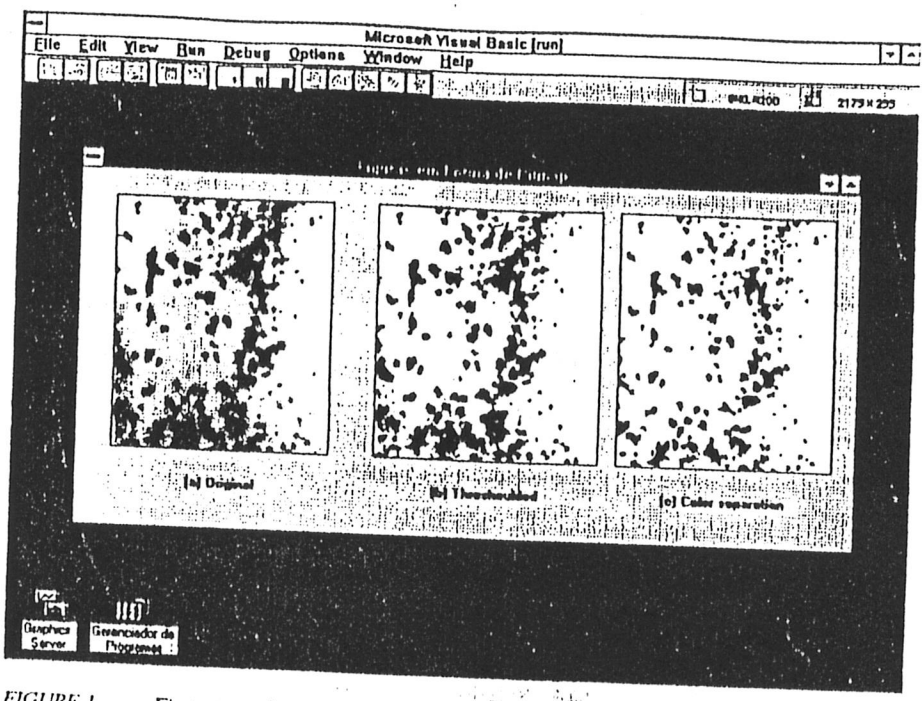

FIGURE 1 - First steps of the evaluation procedure: (a) scanned image; (b) threshoulded image (three levels); (c) separation in two levels for output.

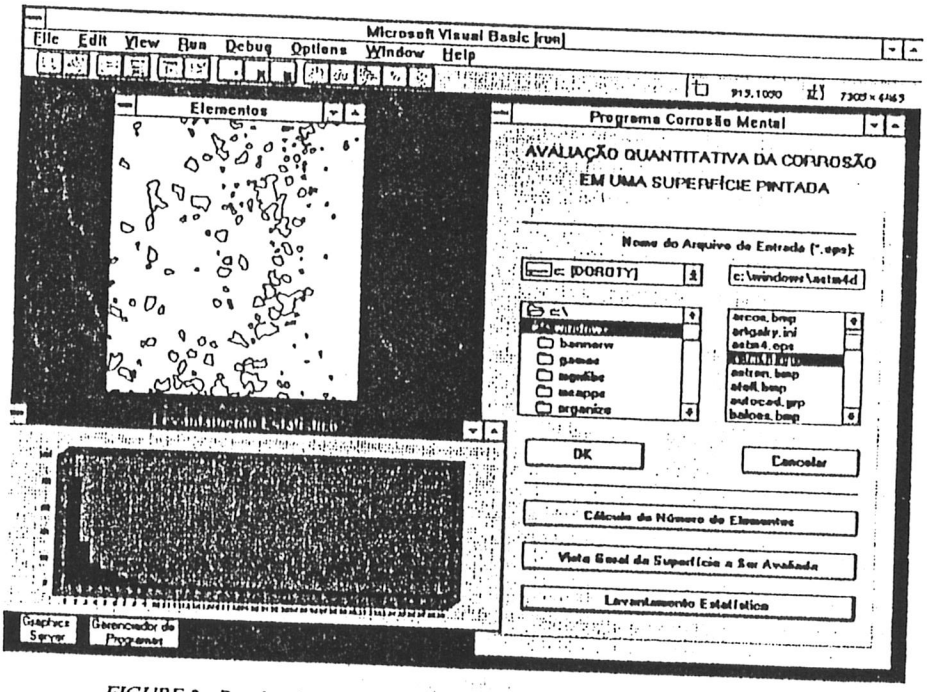

FIGURE 2 - Results obtained for typical rust grade number 6 of ASTM-D610-85.

00004

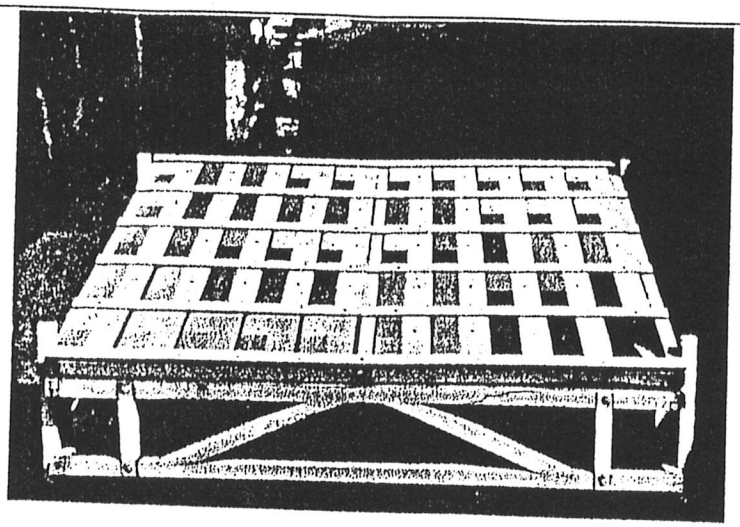

Photo 1 - Test Pieces Exposition

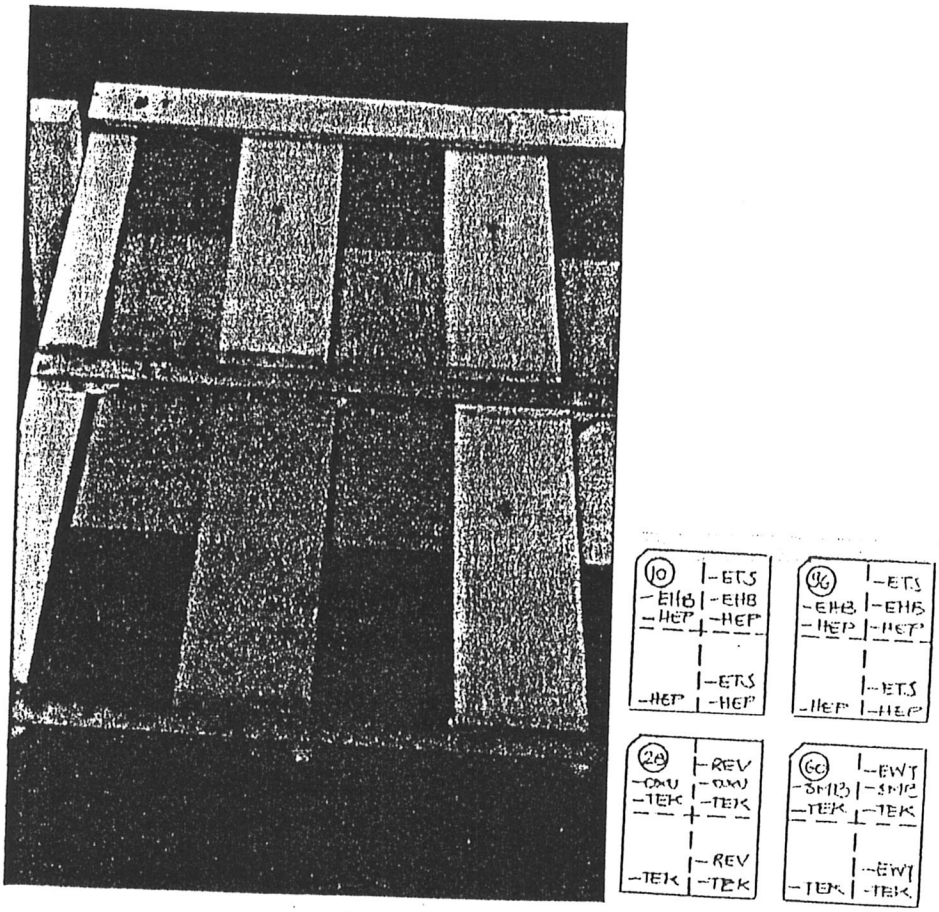

Photo2 - Test Pieces painted with different number of paint layers

00005