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A Novel Automated Technique for Ferrous Materials Classification

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Abstract - The composition of the material and its processing conditions effect the microstructure of that material. Mechanical properties are inturn dependent on the material's microstructure. Thus the study of microstructure is important to asses the material processing conditions. This also helps in forensic analysis of material failure. Metallography deals with the material microstructure study. Classification of Material is the first step of the metallographic analysis. The tonal distribution of the microstructural image is completly dependent on the material and its composition. The current paper proposes a automated technique for classification of materials using image processing algorithms.

Keywords: *Intensity Distribution, Image processing, Metallography, Microstructure.*

I. INTRODUCTION

The composition and processing conditions of a material effect properties. These also determine the microstructure of the material. Thus analysis of microstructure helps in assessing the processing conditions as well as its composition. This step is, thus, of great importance in forensic analysis for determining why material failed. In quantitative Metallography, material recognition and classification is the primary step. It may be noted that the available standards require comparison of the microscopic image of the microstructure with standard image. Human factor, thus, has a great influence on the accuracy of this process. In this paper an effort has been made to automate the image comparison process so as to avoid the deviations due to human factor. Use of the automated techniques for material classification has the following advantages: (i) increase in speed and accuracy, (ii) expansion of solved tasks, (iii) results can be given as input for other applications.

Various algorithms developed till now for material classification are mostly limited to a set of materials or consisted of length procedures. Mikhail V. FILINOV, et al ^[1] proposed software SPECTR MET in which the classification required definition of qualifiers. Mohammad E. Hoque, et al ^[2] proposed a tool using pattern recognition for measuring changes in microstructure during heat treatment. Hong Jiang, et al

^[3] proposed an image processing technique using ANN for quantitative analysis on microstructure of Grey Cast Iron. S. Missori, et al ^[4] studied the effect of changes in microstructure on mechanical properties of stainless – caldded carbon steels. L.C.Kgomari, et al ^[5] studied the effect of microstructure on the properties of HSLA steel. Metallographic procedures are discussed in [6], [7] and [8]. Image processing techniques are discussed in [9].

The current paper proposes an automatic technique for classification of materials based on microstructural images. In the ensuing sections, the proposed histogram technique for classification of ferrous materials is discussed in detail and with examples.

II. HISTOGRAM OF AN IMAGE

Histogram of an image is the graphical representation of tonal distribution in that image. Histogram gives the basic information regarding the image like distribution, central location (mean, median, and mode), width of spread (range and standard deviation). The information thus obtained can be used for further processing like histogram matching, thresholding, edge detection, image segmentation and pattern matching.

For grey images histogram is required for one color component only. When considering colored images, histogram has to be considered for individual components depending on the color – model.

In the current paper, histogram comparison is performed for matching the images. In the present work, an attempt has been made to compare the histograms of individual color components of test specimen image and standard images for their parameters like median and histogram height. The work comprises of developing an algorithm which automatically generates the histograms of the three color components Red, Blue and Green. The images below show the microrstructural images of some materials and their corresponding histograms.

Φιγ 1(α): Αλ Αλλοψ Στεελ Μιχροστρυχυρε

Φιγ 1(β): Ηιστογραμ οφ Αλ Αλλοψ Στεελ Μιχροστρυχυρε

Φιγ 2(α): Αυστενιτε ιν Στεελ □ Μιχροστρυχυρε

Φιγ 2(β): Αυστενιτε ιν Στεελ □ Μιχροστρυχυρε Ιμ αγε Ηιστογραμ

Φιγ 3(α): Γρεψ Χαστ Ιρον Μιχροστρυχυρε Ιμαγε

Φιγ 3(β): Ηιστογραμ οφ ΓρεψΧαστΙρον μιχροστρυχτυρε

Φιγ 4(α): Λοω Χαρβον Στεελ Μιχροστρυχτυρε

Φιγ 4(β): Ηιστογραμ οφ Λοω Χαρβον Στεελ Μιχροστρυχτυρε

Φιγ 5(α): Μιχροστρυχτυρε Οφ Μιλδ Στεελ

Φιγ 5(β): Ηιστογραμ οφ Μιλδ Στεελ Μιχροστρυχτυρε

Φιγ 6(α): Τοολ Στεελ Μιχροστρυχτυρε

Φιγ 6(β): Ηιστογραμ οφ Τοολ Στεελ μιχροστρυχτυρε

It can be seen from the above images that the histogram for each microstructural image varies depending on the type of material.

It may also be noted that the images are grey level images. And thus histograms of the three components (Red, Blue and Green) are coinciding and are being shown as a single line. The use of the above histograms is discussed in *results* section.

III. METALLOGRAPHY

Metallography is the study of material's microstructure. Accurate, sharp delineation of true microstructure of materials is of great importance in the characterization, composition, structure and properties of materials. Metallography includes a wide field in material investigation. It bridges the gap between the existing materials and new materials. Microstructure is characterized by size, shape, arrangement, amount, type, orientation of phases and defects of these phases as schematically shown in figure 7.

Φιγυρε 7: Χονσττυεντο οφ μιχροστρυχτυρε ανδ φαχτυροσ αφφεχτυνγ τηεμ

The basic steps in metallographic analysis include documentation, sectioning and cutting, mounting, planar grinding, rough polishing, final polishing, etching, microscopic analysis.

During the metallographic analysis, once the specimen is prepared using the above mentioned processes, the specimen is observed under microscope and the microstructure is compared with standard microstructures so as to determine the type of material. The stepwise representation of the metallographic process is shown in the figure 8. The developed tool is used to aid in Microscopic analysis. This makes the analysis faster, more accurate and the results can be used for further analysis. A detailed description of the experimental setup, program and results are discussed in the following few lines.

IV. EXPERIMENTAL SETUP

Experimental setup used for the metallographic analysis is shown in figure 9. The setup comprised of a CMOS camera with 10x lens (eye piece) mounted onto a microscope.

A program has been developed in Java for comparing the image of the test specimen with standard images. During the comparison, image histogram height and median are compared. A maximum of 10% deviation in histogram height and 5% deviation in median of histogram are considered as allowed deviations.

The flowchart showing the implementation is given in figure 10. Developed tool UI is shown in figure 11.

V. RESULTS & DISCUSSIONS

Once the test specimen image is loaded into the software, the histogram of the, histograms of Red, Blue and Green components of colors are individually generated (Figures 12 a, b, c & d). The generated histograms are then compared with those of the standard ones. When a match is found, the plots of histograms of the RGB components are generated in separate graphs for validation purpose. It may be noted that all the images are of 640 X 480 pixel size.

VI. CONCLUSION

Metallography deals with the analysis of microstructure of the material which involves classification. In the current work, an attempt was made to classify the material based on the microstructure image histogram. A tool was developed for automating the image comparison process. The results of this tool

are presented in this paper. The output of this tool can be used as input for further quantitative analysis.

Φιγυρε 8: Μεταλλογραφησ στεπς

Φιγυρε 9: Εξπεριμενταλ σετυπ

Φιγυρε 10: Ιμπλεμεντατιον αλγοριτυμ

Φιγυρε 11: ΥΙ οφ τησ τοολ δεπελοπεδ

Φιγυρε 12(α): Τεστ Σπεχυμεν ιμαγε

Φιγυρε 12(β)

Φιγυρε 12(χ)

Φιγυρε 12(δ)

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