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Review on Image Enhancement techniques of Microstructural Images

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ABSTRACT: Microstructure is defined as the structure of surface of the given material as obtained from a microscope above 25x magnification. The microstructure of material can strongly influence physical properties such as toughness, strength, corrosion resistance, ductility, high/low temperature behavior, wear resistance and many other mechanical properties. The microstructure of materials greatly influence the applications of materials. The microstructural images are obtained and they are processed. In this paper, review on enhancement of microstructural images is done about using the various digital image processing techniques. Digital image processing is used for fast and accurate analysis of materials.Quality control is most important in production of materials. So in this paper, we have studied various papers and presented the techniques used to achieve their objective.

KEYWORDS: Microstructural images ,morphological operations, segmentation, edge detection, background suppression.

I. INTRODUCTION

Digital image processing is very important in industries. As technology advances, the development of procedures to obtain desired results have become faster and accurate. Everyday huge amount of images are captured in industries and they are processed and results are obtained i.e.desired features of images. When images are processed manually it takes up a lot of time and effort and also the errors can be more. So image processing technique are applied so that the results can be accurate and faster.

Enhancement of microstructural images using techniques of digital image processing is very essential since the output from the equipment is not clear image. The images obtained are not high resolution images ,so the images are enhanced by preprocessing and other various image processing techniques.

The main objective of this paper is to provide a literature study on various papers that provide different techniques to enhancemicrostructural images and in quality control and manufacturing products.These methods are mainly used in industries .

II. EXISTING METHODS

Many researchers have worked on microstructural images and found desired results by image enhancement techniques.In this, those papers are described briefly as follows:

A method that detect defects and classify them with a high rate in a short period of time is proposed by G.M.AtiqurRahaman. In this paper the image is obtained i.e Image acquisition is done and then Image Enhancement ,noise reduction and the edge detection is applied. After those steps by using the proposed algorithm whether the defect is present or not is found. If yes,morphological operation is applied and the defects in the image is classified and the result is obtained. To obtain the image, Samsung Climax W54 digital camera is used and trimmed with a size max since the image must have equal size. Next, In image enhancement,RGB image is converted to grey level image.Then the contrast stretching is applied to stretch the range of intensity values which is done using the equation

$$O(x,y)=(I(x,y)-min)(ni/max-min)+i$$

Then noise reduction is done by applying non-linear filter i.e.median filter which is better in removing salt and pepper noise. After that the sobel edge detection is used because of simple calculation and high speed. To determine whether there is a defect or not all these preprocessing techniques are applied to a test image of a reference image and they are

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taken in matrix form to compare number of black pixels. If the test image has higher black pixel,defect is present. If the defect is present then the type of defect is identified. There are lot of defect like pinhole, crack defect ,blob defect, spot defect, edge defect and corner defect. Separate algorithms are proposed in this paper for each defect and before classification of each defects they find if the tiles are plain or printed. The results they conclude after applying these algorithms is the comparison of existing method and proposed method. They compare the speed and efficiency of both algorithms.

A digital image processing technique for analysis of Iron microstructure is proposed by Dr.P.G.Mukunda . The source image can be captured through analog camera or digital camera or pin hole camera. In this it is captured from a microscope with a digital camera and the microscope can be magnified up to 120 times. The obtained image is corrupted due to transmission and so preprocessing is applied to remove noises due to structural defects and transmission. Then noise filtering techniques are applied to suppress noise and make the image more clear. Median filtering is applied as it processes the sharp edges than the other filters.

The image enhancement process is done to give a better input to the system. The color information and texture information is taken from the image. Image histogram is used here in enhancement to give the graphical representation of number of pixels versus intensity. The histogram gives view about contrast and overall intensity distribution of an image. By analyzing the peaks and valley of the histogram they have determined what range of pixel intensities are in the grain that shows the object in the image and the remaining is taken as background. The histogram is given by

$$S_k=T(T_k)=\sum^{k}_{j=0} nj/n$$

Where S is the level of every pixel value, r is the original image T() is the transform function, nj is the number of times this level appears in the image, n is the total number of pixel in image.

Then image thresholding is done along with edge detectors to highlight the strong edges and weakens the weak edges. They set two levels of values. One level is the maximum threshold above which the pixels are made zero and another is minimum level below which the pixels are made 255.The pixels between the two level remains unaffected. Then the edge detection is done to identify grain boundary of microstructural image. Since edges hold much information it is an important stage. It tells where the grains are located and also tells about shape, texture and size. The edge detection operations like prewitt and canny are used here. The results obtained shows them the image in a way that they can count number of features by eliminating the regions.

The microstructural analysis of iron using hybrid image processing approach in order to determine the quality assessment parameters such as nodule size, count, nodularity,etc is proposed by Dr.V.jayashree. For the analysis they have used segmentation, boundary detection algorithm and artificial neural network. The segmentation is done by otsu's thresholding method. Next the boundary edge detection is done by morphological operations and then artificial neural network is used to determine nodule size and nodularity of nodules in castings. The total number and diameter of nodules is the input for artificial neural network. The different quality parameters are obtained from the results. They are obtained by using many methods or formulae. To find roundness of nodules.The roundness matrix formula is as follows,

$$r_m=4*\pi*(area/perimeter^2)$$
$$\text{Then area of nodule} = \pi r^2$$
$$r^2=\text{area of nodule}/\pi$$
$$\text{Diameter, } d=2r$$

And nodularity= No. of exact round nodules / total no. of nodules.

They have carried out the second part of experiment to find the % of ferrite-pearlite in SGI castings. After etching, the images are resized and segmented. The number of black and white pixels are calculated and the number of white pixels is ferrite and number of black pixels is pearlite. According to diameter of nodules, the size of nodules are classified. In this they have also automated the results obtained from manual methods and have generated the reports.

The microstructural analysis and enhancement of nodular cast iron using digital image processing method in order to find quality factors is proposed by V.Sakthivel. When microstructure images are usually captured by camera, they often

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have superimposed noise which is usually impulse noise which occurs in the image as dark spots. The noise occurs due to chemical reaction or scratches in the image.

So this paper, To enhance the images, steps such as segmentation, preprocessing, edge detection and filtering are applied on the images. The first step is segmentation that is done by giving threshold values. Next step is edge detection to detect grain boundaries and to do detailed study on mechanical property such as ductility, malleability,etc. It uses a edge function as follows D-(D XOR B). This paper mainly focuses on filtration techniques. They have proposed a new technique called resolution based median filter which restores more than 95% of original image, when the normal method just has 30% restoration of original image. In RBMF algorithm, the corrupted image pixels are replaced by noise free reliable pixels. There are many steps in RBMF to remove corrupted pixels that occurs due to sampling, grinding, polishing and etching.

RBMF uses various formulae such as

$$\alpha^k{}_n=\{l=(l_1,l_2/n)-(k-1/2)\leq l_1\leq n_1+(k-1/2),n_2-(k-1/2)\leq l_2\leq n_2+(k-1/2)\}$$

After applying RBMF, the image is restored and various edge detection operators are applied to find grain boundary. The edge detections applied are prewitt, sobel, Roberts and canny. Prewitt is used to find local edge orientation for each pixels by calculating maximum response of set of convolution kernels. Sobel gives better noise suppression in image. Canny finds the image gradient to highlight regions and also smoothens the image. Roberts calculated the square root of magnitude squared of the convolution. After all these processes the mechanical properties are found. The nodule count study is needed to find metallurgical quality of graphite. As the nodule count increases, the size and shape of nodular can iron decreases which enhances mechanical properties.

The metal implants degrades image quality and limits the applications of metal.SoDr.E.Kirubakaran has proposed a method to extract texture features and to detect pitting and laminating defects and also to find exact level of defect. For many years, the streak in images are found by many methods, they can be clarified as iterative and interpolation base methods. Metallic rods with cracks are most dangerous as they can cause fatal accidents or great loss if used in construction. So to find them automatically and without delay this method is proposed. In this first, the images are prepocessed and then the edges are detected. Then based on full metal image analysis, component based representation with LDA is done. To simplify the modeling of image statistics, the image is partitioned into several metal components. These components are encoded by LDA to equalise the effect of illumination. LDA is then applied to collection of component based LDA referred as cascaded LDA. LDA is Linear discriminant analysis. The concept implemented is fractional wavelet transform. It has capability of signal representation in fractional domain. Then the diffusion methods are implemented and this paper has three types

- Linear isotropic diffusion
- Non-linear isotropic
- Anisotropic non-linear diffusion

In texture analysis, the images can be segmented based on textures. The first step is image acquisition and then preprocessing and feature extraction is done and images are classified. It has two phases as learning phase and recognition phase. In learning phase, the system is trained with data images and in recognition phase the images are tested and then diffusion process is applied and results are given by them. The lamination and pitting defects can produce poor bonds between layers or poor surface finish, so they must be found and eliminated. So diffusion method is used. In this paper, the results shows the feature extraction and the lamination and pitting defects graphically and after that noises are removed from the images.

Canny edge detection can be used to detect grain boundaries of the crystals.This method is proposed by M.Varadhalakshmi. Grain boundary js the interference between two adjacent crystalline domains. To study about crystals grain boundaries are important. Size of grains and atomic structure of grain boundaries dominate the properties of polycrystalline materials. This paper mainly deals with detecting edges of grain boundaries in crystals of SEM images. So to find grain boundary, image processing techniques such as Image acquisition, Image Segmentation and feature extraction are applied.The images are obtained from SEM with good resolution. The images are in index form and then they are converted into binary form by thresholding. By thresholding, the image retains all structural

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properties of image but loses color and texture information. The obtained binary image normally has noise so filtering technique is applied. So in this they have used a 2D adaptive weiner filter to remove noise.Then edge detection operation is proceeded.

Canny edge detection is used to find both strong and weak edges of each particle. It smooths noise and then computes the edge strength and direction for each pixel in smoothed image by using linear filtering with a Gaussian kernal. This is done by differentiating the image in two orthogonal direction. The arctangent of the ratio of derivatives is used to compute gradient direction. Edge pixels are pixels that survived thinning process called non maximal suppression. In this method, edge pixel value is set to zero if the edge pixels of adjacent pixels is larger in gradient direction. They have used algorithm that gives complete grain boundary.

The image is smoothened by performing convolution with Gaussian of variance. Then the gradient of image and its magnitude and direction are computed. Then the pixels where gradient magnitude has local maximum in direction of gradient is selected. Two thresholds are selected as T1 and T2.If selected pixels with gradient magnitude larger than T2 then it is strong ,if magnitude is between T1 and T2 then it is weak. Then all the strong pixels and all weak pixels connected to strong pixels are selected. In this paper the canny edge detection is used to find grain boundaries of alkaline crystals.

The method to find defected metals from fresh metals is proposed by J.S.Chitode.As defected metals can make the quality of production to be reduced this method proves useful. Various defects like pin holes, scratches, etc are very difficult to be detected by naked eyes. So to find defects faster, image processing techniques are applied to detect and classify the defects. Machine fails due to various reasons. One of the reasons is degradation and that is due to corrosion and mechanical wear. So these defects must be detected at early stages of production. This paper uses Gabor filter that are defined by harmonic functions that is sinusoidal functions modulated by Gaussian distribution. Gabor filter has limitation beyond certain frequency bands except that it is similar to Fourier filter. It is also termed as short time Fourier transform. With the help of this filter, they transformed the signal to time frequency domain after which the signal is processed. After this the transform is inversed and the signal is obtained .It can also decompose the image into components depending on different scales and orientation. The impulse response is given as

$$h(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\left\{-0.5\left[\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right]\right\} \exp(j2\pi Fx')$$

This has real and imaginary components as follows

Real

$$h(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\left\{-0.5\left[\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right]\right\} \cos(2\pi Fx')$$

Imaginary

$$h(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\left\{-0.5\left[\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right]\right\} \sin(2\pi Fx')$$

The image is first obtained from industries and then given to gabor filter bank with test and reference images. After that feature extraction is done by comparing test image and statistical values. i.e mean and standard deviation of reference image. Then unique image is obtained by data fusion. After this thresholding is applied to find whether defect is present or not. If the defect is detected bounding box calculation is done to classify the defect. The proposed algorithm is experimented on images with defects . Gabor filter consist of parameters such as face offset orientation,band width, wavelength and aspect ratio. Wavelength and bandwidth of the image affects the filter response. The proposed method can be used for examining other types of material such as plastic, wood, fabrics, etc. This method successfully detects the defects of different size, resolution and orientation and it is proved to be robust.

A new method for explicit analysis of surface defects is proposed by T.Aarthi.Structural damage is one of the factors that causes machine breakdown. The structural damage generally results from textural irregularities on outer surface. This paper is about developing a discrete wavelet transform technique to diagnosis defect in machineries. The structural damages are detected using wavelet analysis. The basis idea behind wavelet transform is to produce differencing operations and smoothing operations at each level maintaining same number of pixels in the image in each level. At first, the image produced is low resolution image. It produce 3 edge detection image as

- Horizontal component image
- Vertical component image
- Diagonal component image

This four image can be reconstructed into original image. This is level 1. In level 2,the wavelet waveform in applied on level1 smoothed subject image. These iterative process continues.Level3consists of 1/64 size image smoothed subimagewhich is obtained from level 2 sub image. The original image can be obtained from level 3 image also. Haar wavelet is very effective in edge detection . It is a sequence of square shaped function which together form a wavelet function family. It allows target function over an interval to be represented as in terms of orthogonal function basis. Disadvantage of haar wavelet is that it is not continuous. The image is denoised and thresholding is done . Then feature extraction is done. The mean, standard deviation, skewness, kurtosis and variance value table is constructed for uncracked and cracked images. It can be observed that cracks images have low pixel values. The inclination angle of crack is also analyzed in this paper. Detection of cracks is most important criterion of this paper.

The paper to quantity the amount of autensic and martensic phases and to detect its morphology modification along to the processed region by BarcellonaAntonia.They give image enhancement algorithm for optical microstructural characterization of shape memory TiNi friction stir processed. In order to evaluate the effectiveness of solid state joining on maintaining of shape memory properties, TiNi sheets were friction stir processed. The TiNi metals when melted,shape memory may disappear. To overcome blurring due to microscopic optics, the wavelet transform emerged has noise in it and image denoising techniques are used and it has two steps of analysis i.e. wavelet based transform and texture segmentation techniques that have been combined to denoise all micro graphic image. The 2D discrete wavelet transform and 2D Haar wavelet transform are applied to images and 5 level decomposition is done until there is only autensic and martensic phases. By combining 1D Haar scaling function equation and Haarwavlet equation, the following expression are arrived

$$\Psi_{j,m}(x) = \frac{1}{\sqrt{s^j}}\,\psi\left(\frac{x - m\tau\ \ s^j}{s^j}\right)$$

$$\Phi_{j,m}(x) = \frac{1}{\sqrt{s^j}}\,\Phi\left(\frac{x - m\tau\ \ s^j}{s^j}\right)$$

The decomposition process of DWT split up the arising into many low components and iterated for a suitable number of levels. The iteration may proceed until detail consists of single pixel so the number is limited. The images are divided into submatrices.
Submatrix LL that represents approximation
Submatrix LH that represents details across horizontal direction
Submatrix HL that represents details across vertical direction
Submatrix HH that represents details across diagonal direction
The denoised images are converted into gray scale images and are enhanced by means of histogram equalization. Then texture segmentation followed by binarization to classify autensic and martensic phases in the image.

III. CONCLUSION

The testing of various metals and ceramics is done by implementing microstructural analysis .We learnt about various methods like Resolution based median filter,Canny edge detection, Haar transform, DWT, Gabor filter, Weiner filter and LDA.These methods are very useful in finding the various defects in materials and in quality control.The microstructure also explains about the mechanical and physical properties of the materials.

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