

Image enhancement algorithm based on Retinex for Small-bore steel tube butt weld's X-ray imaging

YAOYU CHENG, YU WANG, YAN HU

National Key Laboratory for Electronic Measurement Technology
College of information and communication engineering, North University of China
Taiyuan City, Shanxi Province (Post Code: 030051)
CHINA

E-Mail: chengyaoyu66@163.com <http://www.nuc.edu.cn/>

Abstract: - It is very common to use X-ray digital detection for the Small-bore steel tube butt weld. But the X-ray images have some shortcomings such as that contrast is not high, background noise is big, and the details can not be shown obviously, these shortcomings take a great inconvenience for the small-bore steel tube butt weld testing. So the detection efficiency can not be increased. Based on this, the Retinex algorithm is discussed and analyzed, such as single-scale of Retinex, multi-scale of Retinex, alterable framework of Retinex. Then it is applied to use an enhancement algorithm of improved Alterable framework on Retinex, and use this enhancement algorithm for X-ray image. This enhancement algorithm do not ask for much contrast of original image, which can effectively improve the original image contrast and image quality, the details of the image achieve the best visual effects. After the theoretical analysis and experimental results, we can see that, this enhancement algorithm can effectively enhance the image contrast, inhibit the background noise, compared with homomorphic filtering and histogram equalization algorithm. The standard of the image which is processed by this method can achieve the higher testing standard compared with homomorphic filtering and histogram equalization algorithm.

Key-words: - radiographic image; image enhancement; Retinex algorithm, single-scale Retinex algorithm, Multi-scale Retinex algorithm, alterable framework model, butt weld

1. Introduction

X-ray imaging system has been widely applied in industrial non-destructive testing. In the boiler pipe butt weld detection, it has a wide range of applications. Ray imaging has a direct impact on the efficiency and quality of the weld detection. In the X-ray imaging systems, because of the contrast of radiography, the non-definition of radiography, and a variety of constraints of hardware, its image is existed characteristics such as big noise, low contrast, image blurring, image detail information has been submerged by the noise, the image quality difficult to

achieve the required industry standards. Effective image enhancement algorithm can filter out system noise and background noise, enhance the image contrast, and the details of the workpiece will be separated from the background, so that clear display of the details.

There are so many X-ray image enhancement algorithm now, but these methods have good results only for some special images, for example, histogram equalization have good results when the original image with low gray-scale, but when the image with high gray scale that show many details, this enhance method can not be satisfactory results; when the

image has a greater difference in brightness, homomorphic filter will engender more feint. Actually, X-ray image have very low brightness and many background noise, it can not distinguish the information of image detail in the dark region whit conventional enhancement methods, so it need an effective image enhancement algorithm, not only to enhance the image details of information in the dark region, but also to suppress the system noise and background noise, in order to better display the image.

To this end, this paper contraposes the characteristics of X-ray images and the inadequacy of conventional enhancement methods propose variable framework model of Retinex algorithm for the X-ray image enhancement, it is to meet the needs of industrial X-ray inspection standards to improve the detection efficiency and quality.

2. Retinex Theory

Color is important information source to describe, distinguish and identify an object for human and other biological visual system. In the image, the object can be displayed in different color saturation and has nothing to do with the change of the light. The human’s visual perception is more sensitive to the reflection light of the object’s surface. To this end, Retinex theory is introduced by Land to explain human’s visual model, and establish illumination invariance model of which the color has nothing to do with. The basic objective of Retinex model is carry out image reconstruction, making the image after reconstruction the same as the observer saw the images at the scene.

Retinex model is based on reflection imaging illumination model ,it is very similar to homomorphic filtering: irradiation light is more smooth than the changes of reflected light, you can use low-pass filter to estimate the fuzzy computing on the input image; reflected light is divided from the input image and smooth images.

Retinex ("Retina" and "Cortex" abbreviate) is proposed by Edwin Land is different from the traditional image enhancement algorithm, such as

linear, nonlinear transform, image sharpening and so on, that can only enhance particular type of characteristics of the image, such as compress the dynamic range of images, or image edge enhancement, etc., Retinex balance three aspects in compress the dynamic range of gray-scale, edge enhancement and color constancy, which can be use with different types of images and self-adaptive enhance.

Retinex basic principles are to be divided into an brightness image and reflection image, then enhance images to achieve the purpose by reducing the impact of image brightness on reflection image According to Land's Retinex model, an image can be defined as $S(x, y)$, is shown as fig1:

$$S(x,y)=R(x,y) \times L(x,y) \dots\dots\dots(1)$$

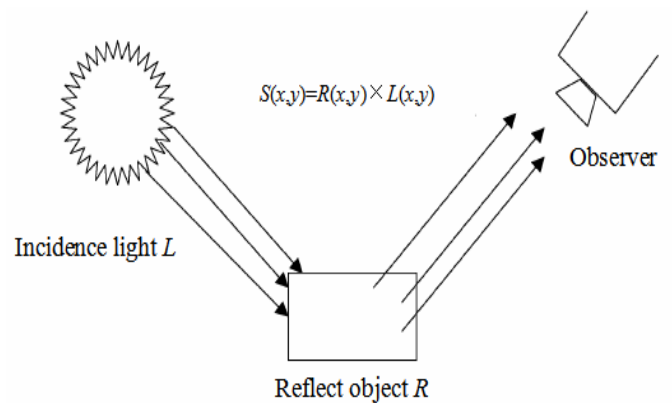


Fig1 Schematic diagram of Retinex

R express the brightness of the surrounding environment, has nothing to do with the objects, and L is the reflectivity of objects, has nothing to do with the lighting, which includes details of the characteristics of objects.

The algorithm process of Retinex of is shown as Figure 2:

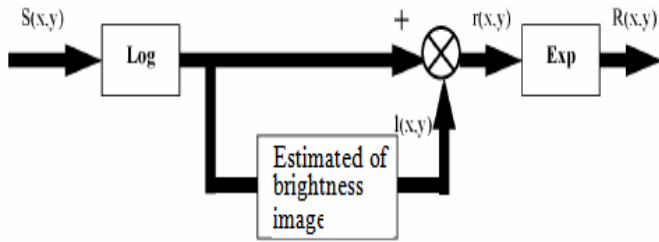


Fig 2 The algorithm process of Retinex

The key of the Retinex theory with image enhancement is calculated the brightness image from the original images effectually, but calculated brightness image from the original image is a non-problem in math, it can only be estimated through mathematical approximation to estimate image brightness.

In the process of development of Retinex theory, according to the different methods of image brightness estimates.

There is a number of image enhancement methods based on the Retinex theory, such as the random walk algorithm, Poisson's equation algorithm, homomorphic filtering algorithm, single-scale Retinex algorithm, multi-scale Retinex algorithm, McCann's Retinex algorithm, the latest variable Retinex model, etc.

2.1 single-scale Retinex algorithm

Single-scale Retinex algorithm is the improvements and realized for Center / Surround Retinex (Center Surround Retinex) in 1997 by Jobson and his colleagues. $I(x, y)$ for the original image, $L(x, y)$ for the brightness function, $R(x, y)$ for the reflectance images, single-scale Retinex can be expressed as formula 2:

$$\log R(x, y) = \frac{\log I(x, y)}{\log L(x, y)} = \log I(x, y) - \log [F(x, y) * I(x, y)] \dots\dots\dots(2)$$

$F(x, y)$ is the low-pass convolution function,

which is estimated brightness image $L(x, y)$ from the original image.

According to the visual theory, because of the existence of lamp-house brightness and objects' reflect at the scene, which correspond to the brightness image and reflection image. That is the reason why human eyes can see the objects. Which color of light can be reflected is decided by the nature of the object itself, not changes because of the light source or light brightness.

Thus 4.9 show that, removal the impact of brightness image in the original brightness, the nature of light reflection color can be gained, which is color constancy

At the same time, the human eye is more sensitive for the gray edge, such as high-frequency information that, due to the convolution function in 4.9 is a low-pass function, so $F(x, y)$ is estimated the brightness of the image $L(x, y)$ correspond to low-frequency part of the original images. Low-frequency part $L(x, y)$ of the image is removed from the original, which is single-scale Retinex, received original description of high-frequency part, that corresponds to the edge of the image. Therefore, not only color constancy can be achieved, and edge enhancement can be achieved by the single-scale Retinex

According to optical theory, assuming that $Q(x, y)$ is the source brightness distribution of the air space, $W(x, y)$ is the reflection light's distribution of scene objects. The distribution of the light reflection in the eyes can be described as 3:

$$R(x, y) = \log \frac{Q(x, y) \bullet W(x, y)}{Q(x, y) \bullet W(x, y)} \dots\dots\dots (3)$$

$\overline{Q(x, y)} \bullet \overline{W(x, y)}$ is the product of light source

in space distribution and the distribution average of reflection light multiplied, describing the brightness of objects in the eyes. Brightness light source is usually the same, that is, formula 4

