The application of enhanced technology of radiographic image based on Retinex

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Abstract:- In order to improve the shortcomings of X-ray imaging such as low contrast, apparent noise of background and the details of the workpiece can not be shown, Alterable framework model on Retinex algorithm appeared. It strengthens characteristics of X-ray imaging and improved the contrast and the quality of the original images, and the best visual effects of the minutia area are achieved. The theoretical analysis and the result of the experiment indicate that this algorithm compared with other algorithms, such as Homomorphic Filter and Gray Equalize which can effectively enhance contrast, control the context and noise. After enhanced the radiographic images by using this algorithm, the images will have better contrast than the first and second algorithms.

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

1. Introduction

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

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

\[ S(x, y) = R(x, y) \times L(x, y) \] ........(1)

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 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.

3. Alterable framework model based on Retinex theory

Alterable framework model set up the assumptions which based on the Retinex algorithm. These assumptions include:

(1) Incident light \( R \) has the characteristics of spatial smoothing.

(2) Since \( R \) is limited to \([0, 1]\) and is monotonous on log-domain, so the image of incident brightness component has: \( S \geq R \).

(2) Incidence component \( L \) should be as close as possible to the output brightness of the image.

(3) Incident light in the image borders should have smoothness similar constant.

Based on these assumptions above on, Kimmel and others give the following equation:

\[
F[L] = \int_{\Omega} (\| \nabla L \|^2 + \alpha (L - S)^2 + \beta | \nabla (L - S) |^2 )dxdy \quad (2)
\]

Subject to: \( L \geq S, \text{ and } \nabla L, \tilde{n} = 0 \text{ on } \partial \Omega \)

In the type above on, \( \Omega \) is image, \( L \) is the brightness image, \( S \) is original image, \( \partial \Omega \) express image edge, \( \alpha \) and \( \beta \) are non-negative coefficient. \( | \nabla L | \) of the above formula makes the image brightness spatial smoothing. The condition \( (L - S)^2 \) made the brightness image near the original image, the difference between these is the reflection images. \( | \nabla (L - S) |^2 \) is similar to Bayesian expressions, so that the reflection images have been better suited to visual characteristics.

If we can find the numerical solution of this equation, we will receive the brightness image \( L \), and then realized image enhancement with Retinex algorithm.

4. Image enhancement algorithms for X-ray Image base on an improved Alterable framework on Retinex

Although the above model can correctly solve the Retinex problem, but it has several shortcomings:

(1) Halo: Halo's existence are often encountered in Retinex algorithm. It is a direct result of smooth assumptions as described above.

(2) Noise: In the Image of darkness regional Retinex algorithm will try for a contrast it is very similar to the effect with standard Gamma correction.

(3) Iterative Solution: The above model naturally lead to an iterative solution required.

In view of the deficiencies above the alterable framework of the Retinex, the new assumptions used to improve the variable framework of the Retinex to solve the halo and noise problem, and gains a new iterative formula.

4.1 The realization of improved alterable framework of the Retinex algorithm

Based on the analysis above, the model required some modifications. Analyses the equation of variable framework model

(1) The first restriction \( | \nabla L |^2 \) of the equation is in order to impel the incidence heft as spatial smooth as possible.

(2) In the variable framework of the model, the third restriction \( | \nabla (L - S) | \) is in order to \( R \) as smooth as possible, \( \). The strength of the restriction is decided by the free parameter \( \beta \).

(3) The second restriction conditions \( L \geq S \) is in order to make \( L \) as close as \( S \), which means that \( R \) should be small as possible. However, in order to not make \( L \) excessively near \( S \), \( \alpha \) should be small as possible.

After taking into account the effect of image enhancement, here should be \( \beta = 0 \) and \( \alpha \to 0 \).
Under the new assumptions, gained the new equations:

\[
\begin{align*}
\forall (x,y) \in \Omega \\
\frac{\partial F(L)}{\partial L} = 0 = -\Delta L + \alpha (L - S) \approx -\Delta L \\
L > S
\end{align*}
\] …………(3)

Using the method of steepest gradient descent to solve the equation. Iterative equation as follows:

\[L_s = L_{s-1} - \mu_{\text{PNSD}} \cdot G \] ..........................(4)

\(L_s\) and \(L_{s-1}\) are brightness image in step \(j\) and step \(j-1\) respectively. \(G\) is the gradient images of \(F(L)\).

\[G = -\Delta L_{s-1} \] .................................(5)

\[\mu_{\text{PNSD}} = \frac{\int |G|^2}{\int |\nabla |G|^2} \] .................................(6)

Define the inner product for:

\[\langle G, F \rangle = \sum_{n=1}^{N} \sum_{m=1}^{M} G(n,m) \cdot F(n,m) \] ……………(7)

\(K_{\text{LAP}}\) is Laplace sharpening factor, therefore:

\[\int_{\Omega} |\nabla G|^2 = \int_{\Omega} (G \cdot G - \langle G, \Delta G \rangle) \] ……………(8)

\[G \approx -\Delta L_{s-1} \approx L_{s-1} \ast K_{\text{LAP}} \approx -L_{s-1} \ast K_{\text{LAP}} \ast K_{\text{LAP}} \approx -\Delta G \] …………………(9)

Results can be obtained from the above:

\[\int_{\Omega} |G|^2 = \langle G, G \rangle = -\langle G, \Delta G \rangle = \int_{\Omega} |\nabla G|^2 \] ……………(10)

\[\mu_{\text{PNSD}} = \frac{\int |G|^2}{\int |\alpha \cdot |G|^2 + |\nabla |G|^2 |} \ast 1 \] ……………..(11)

Thus can gain the concluded that if \(\alpha \to 0\) \(\beta = 0\), it will have \(\mu = 1\)

Therefore, the iterative formula can simplify as follows:

\[L_s = L_{s-1} - G \] .................................(12)

This new iterative formula is not only easier, but also effective keep within limits of halo phenomena and noise than the original formula.

### 4.2 Result and analyse

The experiment using the quality standards No. ASTM11 of the United States which is commonly using in ray detection, the workpieces are boiler pipe’s butt weld for 4.5mm wall thickness, using double-wall impact of industrial X-ray irradiation method in the experiment.

1. Original image

![Figure 1](image1.jpg) Original image

2. Histogram equalization

![Figure 2](image2.jpg) Histogram equalization

3. Homomorphic filtering

![Figure 3](image3.jpg) Homomorphic filtering
4. Improved variable framework of the Retinex algorithm

![Figure 4](image-url) Improved variable framework of the Retinex algorithm

X-ray image’s contrast is low, background noise is obvious, and it is not easy to show the details of the measured workpiece. This article aims at characteristics of X-ray image, using improved variable framework of Retinex algorithm. Experimental results show that the algorithm deals with image’s gray-scale with better results, and improves the image contrast, restrains noise at the same time, so that it clearly display the details of X-ray imaging.

**References:**


5. Conclusion

From the figures above, we can see only the third of the image quality meter in the original image, and clearly visible the fifth by deal with improved alterable framework of the Retinex algorithm, meet and exceed the standards of the United States. We can find the comparison that in the circumstances of original image with the information it is difficult to distinguish: histogram equalization algorithm to improve the overall brightness simultaneously, but images edge become blurred and led to a decline in display some details; Homomorphic filtering improve contrast significantly, but this image enhancement method is still not ideal for the dark zone, the image gray-scale is concentrated in the dark zone, the overall effect is dark; and the use of improved variable framework model of Retinex algorithm can be relatively satisfied with the enhanced result, image contrast has been dramatically enhanced, and restrain the noise. Because of this algorithm do not ask for much of the original image contrast, it can effectively enhance the image information in dark areas, so that it can make the image more clearly.

The experimental results prove that this algorithm not only enhances the image contrast, but also restrains the background noise, while making detail of the workpiece more obvious, and the scope of application is wider.