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A research on defect image enhancement based on partial differential equation of quantum mechanics

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Abstract

The image enhancement of aviation material defect is vital for the defect quantitative and qualitative properties. In this paper, a novel defect image enhancement algorithm is presented, which adopts partial differential Equation of quantum mechanics. The algorithm is mainly divided into two steps: according to the quantum mechanics theory, the image edge quantum probability is computed; subsequently, the partial differential equation fusing anisotropic quantum probability is formed to enhance the defect image. Compared with other methods, the experimental results indicate that the proposed method can effectively highlight the defect in aviation material image.

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Keywords: Quantum mechanics; partial differential; image enhancement.

1. Introduction

The composite materials have the advantages of light weight, high strength, fatigue resistance, corrosion resistance and other excellent properties, which are widely used in the missile and rocket engine nozzle and the body shell. Due to the nonuniform distribution of materials, different surface emissivity and noise disturbance, the imaging contrast of composite materials defect is not strong, which will result in the deficiency of recognition and quantification[1-2]. In order to demand the various engineering task requirements, image enhancement should be

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highlighted useful information, weaken or remove some unwanted information, which are conducive to the analysis of human or machine. So, it is necessary to enhance the defect image.

During the past decades, various image enhancement methods have been presented. Many of them, such as adaptive filtering, high pass filtering and median filtering method, due to the lack of defect type and specification knowledge, are not effective[3].

In recent years, the use of partial differential equation(PDE) has been regarded as image preprocessing technique. Perona proposed anisotropic diffusion method using PDE to keep the image edge, but did not solve the balance problem of edge preserving and noise suppression[4]. Meanwhile, quantum signal processing (QSP) is a new research domain of signal processing. The concepts and theories of QSP was first introduced and applied to the image processing by Eldar[5-6]. K.f. Xie proposed a morphological operator of quantum and enriched the theory of morphological image processing[7]. J. Zhang proposed an improved genetic algorithm of quantum to use multi-threshold image segmentation, which achieved effect to a certain extent[8-9].

The paper presents a novel partial differential method of quantum mechanics to enhance the aviation material defect image. The remainder of this paper is organized as follows. In section 2, the partial differential and quantum mechanics theory is reviewed. The framework of partial differential method of quantum mechanics is described in section 3, and the proposed method effectiveness is validated in section 4. The section 5 gives a summary and an outlook to future work.

2. Partial differential and quantum mechanics theory

2.1. PM model

Anisotropic partial differential equations can preserve or enhance edge features while reduce noise in image. PM model is the classical PDE diffusion equation 4, according to the image gradient, which can differently diffuse between the interior region and the boundary region.

$$\begin{cases} \dfrac{\partial g}{\partial t} = div\left(c(|\nabla g|)\nabla g\right) \\ g = (x, y, 0) = g_0(x, y) \end{cases} \tag{1}$$

$$c(|\nabla g|) = 1/\left(1+\left(|\nabla g|/k^2\right)\right) \tag{2}$$

where $|\nabla g|$ represents the gradient modulus, $c(|\nabla g|)$ is the diffusion factor, and div is the divergence operator. If c has a constant value, the expression (1) is called a isotropic diffusion equation. In this case, all pixel points would be smoothed whether the noise or boundary. So, it is obvious that this smoothing is not an ideal manner. To resolve the problem, the diffusion factor c should has anisotropic characteristics. For those points where the gradient moduli are large, their diffusion factors have small value. So, the edges in image are prevented from smoothing. Although the anisotropic diffusion method has better denoising or enhancement performance, it inevitably causes blocky effects and ill-pose problem in the anisotropic diffusion process.

2.2. Quantum mechanics

Bit is the basic concept of classical information theory. In quantum information theory, it also has a similar concept called qubit5. According to quantum theory, for arbitrary quantum state $|\psi\rangle$, it is the superposition of stationary state $|\varphi_n\rangle$. Therefore, the non-stationary state can be expressed as follows.