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Anisotropic diffusion based denoising on X-radiography images to detect weld defects

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ABSTRACT

This paper proposes a machine vision scheme for denoising, feature space gradient preserving, and detecting weld defects in noisy weld X-radiography images; particularly, for the images that are in low-contrast and contain noises. The detection of small weld defects present on noisy image is extremely difficult in non-destructive testing through machine vision. The presence of high gradient magnitude and the low intensity in the feature space of a noisy image are the main characteristics of weld defects. These characteristics can be considered to refine and obtain noise-free images for detection of weld defects. This study proposes a modified anisotropic diffusion model, which considers a local probability value of gray-level and an adaptive threshold parameter in diffusion coefficient function to adjust the implication of low edge gradient of the feature space from the noisy image. Furthermore, an entropy based stopping criterion has been introduced to terminate the diffusion process. This proposed model is compared with the existing models, and its performance is evaluated through Mean Square Error (MSE), Signal-to-Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR), Entropy (E) and Mean Structural Similarity (MSSIM) measures. Experimental results confirm the reliability of the proposed model.

1. Introduction

Ultrasonic, Eddy current, and X-radiography inspection techniques are commonly used in non-destructive evaluation industry. Digital X-radiography has widely been used in Non-Destructive Testing (NDT) and particularly in weld defect detection [1]. The detection of defects depends on the quality of the digitized image, which is subjected to certain factors, such as noise, low contrast, defects of different dimensions, and indiscernible defects in the image background. In experimental sciences, noise refers to any random fluctuations of data that hinders perception of an expected signal. The noise is a summation of unwanted or disturbing energy from natural or man-made sources, and is typically distinguished from interference or distortion. Sources such as automobiles, aircraft, ignition electric motors and switching gear, high voltage wires and fluorescent lamps cause industrial noise, produced by the discharge present in all these operations. Gaussian noise is statistical noise having a Probability Density Function (PDF) equal to that of the normal distribution, i.e., the values that the noise can take on are Gaussian-distributed. In digital images, including those in X-radiography, it is common practice amongst the researchers to model the present noise as Gaussian and apply suitable denoising filters on the image for its quality improvement. Gaussian noise is also called electronic noise because it arises during image digitization process, which is independent of original pixel values and interrupts the gray values during digitization. Moreover, the noisy digital weld X-radiography image reduces the ability to identify tiny weld defects, and it is further worsened if the image contaminated by noises. However, the features present in images are degraded or contaminated by the unknown Gaussian noise levels. Therefore, it is a challenging task to remove such noises without disturbing the image features during noise removal process. To devise a suitable model to remove the unknown Gaussian noise present in the digital weld X-radiography images during denoising and smoothing process therefore turns out to be important.

Incorrect feature extraction leads to detection of inaccurate defects. Moreover, preserving the features present in the Region of Interest (ROI) is considered as severe problem and it is a prerequisite for image interpretation and analysis during denoising and smoothing processes. In this regard, several denoising and

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