Ultrasonic C-scan Image Restoration Using Radial Basis Function Network

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Abstract. A method for restoration of ultrasonic C-scan images is presented by using a radial basis function network. The method attempts to reproduce the mapping between the degraded C-scan image and the high quality one by training a RBF network. The inputs for training are the sub-images divided from C-scan image of flat-bottom hole of size 3mm and the output is the corresponding center in high quality image. After the network was trained, the other C-scan images were used to verify the network. The results show that the network produces good restored results, in which the noise is removed and the edges are deblurred. Comparing the restored results by the networks trained by the different sub-images, the sub-images with size 7×7, scanning step of 3 are determined as the optimal inputs for training.

1 Introduction

Ultrasonic C-scanning is the most widely used method for the nondestructive evaluation of materials and structures [1]. The C-scan image is often degraded with blurriness and noise due to the physical characteristics of the transducer and the inhomogeneities in tested materials. It is difficult to obtain the information of the defects from the degraded C-scan image and thus it results in the decrease in the accuracy of nondestructive evaluation. One way to deal with the problem is to use a focused transducer to increase the resolution of images. Unfortunately, the focused transducer cannot be used in any situation and the parameters of transducer have to be considered with some care. In the same time, there are also many image processing methods based on Weiner filter to restore the C-scan image from the degraded one [2]-[4]. However, the Weiner filters are hard to be determined and implemented since most of them are ill-conditioned problems.

In this paper, a radial basis function (RBF) network [5] was trained to approximate the inverse degrade function of C-scan image to restore the high quality C-scan image from the degraded version.

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2 Model of Degraded C-scan Image

A physical model of C-scan is presented by using the linear shift invariant model. The model gives the following relation:

$$g(x,y) = h(x,y) * f(x,y) + n(x,y) \tag{1}$$

where f is the distribution of defects to be imaged within the interface, g is the degraded C-scan image of f, h is the image degraded function (i.e., the PSF), and n is the additive noise and the other physical effect not included in the convolution model. In frequency domain, this equation can be expressed as follow:

$$G(u,v) = H(u,v) \cdot F(u,v) + N(u,v) \tag{2}$$

Knowing h and n in advance, it is easy to retrieve f from g. Unfortunately, sufficient knowledge about the PSF that depends not only on the characters of transducer but also the tissues in the tested material can hardly be obtained, and the inverse operation is sensitive to noise thus a large error is usually associated with it.

We assume that the degraded function is the integrated results of the transducer parameters with the additive noise. Mathematically, it satisfies the next equation:

$$g(x,y) = D \cdot f(x,y) \tag{3}$$

where D is the integrated degraded function of C-scan image in the spatial domain. Simply, D can be seemed as a nonlinear mapping from f to g. We can build an inverse mapping Q and the restoration of C-scan image is expressed as the relation:

$$f'(x,y) = Q \cdot g(x,y) \tag{4}$$

where $f'(x,y)$ is the optimal approximate image of $f(x,y)$.

It is well known that ANN method is a good tool to deal with this type of problem [6]-[9]. In this paper a radial basis function network was utilized to reproduce the mapping between the degraded C-scan image and the high quality one.

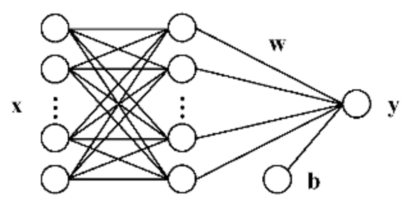

Fig. 1. Structure of radial basis function network