Research of Neutron Backscattering Radiography (NBR) System

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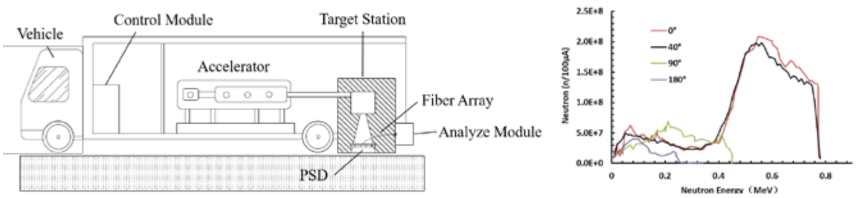
1. Introduction

Neutron is potential to be used as a means for non-destructive testing for infrastructure. However, in some specific situation, like bridge and road detection, the detector is unable to lay out and neutron can hardly penetrate thick concrete. So we need to develop a new method for this situation. Till now, there are very limited studies available on neutron backscattering radiography (NBR). Our group with RIKEN Center for Advanced Photonics first experimented NBR bridge nondestructive testing in 2017. It is verified that backscattering neutron can effectively distinguish water, voids and concrete [1].

Transportable Compact Accelerator-driven Neutron Source (T-CANS) is an effective mean to apply neutron backscattering in infrastructure detection. In this paper, we mainly discuss the neutron backscattering radiography system of T-CANS, simulate the effectiveness of NBR in the field of infrastructure non-destructive testing, and also pre-research the image reconstruction algorithm.

2. Neutron Backscattering Radiography System Based on T-CANS

T-CANS is a potential tool for infrastructure NDT, while the neutron backscattering radiography (NBR) is almost the only way to apply that. Our group has been committed to the development of T-CANS, and make important breakthroughs in key systems. Fig.1(a) shows the structure of T-CANS backscattering radiography system. The source uses 2.5MeV proton and solid lithium target. Fig.1(b) shows energy spectrum of the neutron source.



(a)System Structure (b)Energy Spectrum

Fig.1 Structure of T-CANS NBR System

NBR can effectively distinguish the defects, especially void and water gap. Fig 2 shows the simulation results of defects detection. Defects depth is 10cm, size is 5*5*5cm. Detector size is 30px*30px, pixel size is 0.5cm. Water can reflect more thermal neutron than other material, while void can hardly reflect neutron, thus, NBR can distinguish void and water by means of backscattering neutron flux and energy.

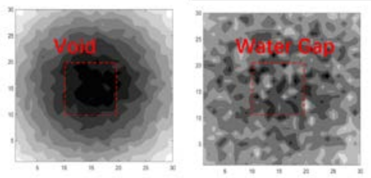


Fig.2 NBR Simulation of Void and Water Defects

3. Super-resolution Reconstruction Based on NT-SRCNN

Super Resolution Convolutional Neural Networks (SRCNN) is a developing super-resolution reconstruction method [2] and already applied in X-ray imaging field. However, due to the lack of neutron image training data, it can hardly apply to neutron imaging. Transfer learning and few-shot learning can effectively overcome this problem. We are developing Neutron Transfer-SRCNN(NT-SRCNN) and successfully apply to transmission imaging [3]. Fig3 is the result of reconstruction, the PSNR has been significantly improved. Furthermore, we will apply this method in neutron backscattering image reconstruction.

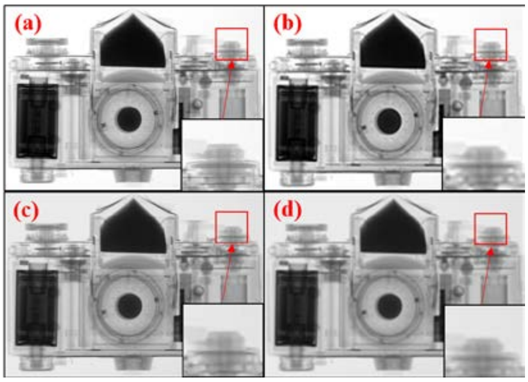


Fig.3 Reconstruction Results

(a) is original image [4], (b) is degrade image of 25% resolution

(c) is NT-SRCNN result with PSNR 32.4db, (d) is Bicubic Interpolation result with PSNR 30.3db

References

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