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AN OVERVIEW OF SOLUTIONS FOR THE USE OF IMAGE FUSION IN NON-DESTRUCTIVE TESTING

Abstract. This paper considers the perspective and state of use of such a method of image processing as image fusion in non-destructive testing.
Keywords: image fusion, image processing, non-destructive testing.

INTRODUCTION

Humanity is confronted with image fusion every day, but the majority are not even aware of it. Each eye works alone collecting data about the environment, but a person sees a single picture. This is possible because of the image fusion performed by the brain.

Image fusion is basically used for increasing the information capacity, if it is not possible to improve this capacity by using classical methods. Additionally, it is used for combining several images of different modalities into one information object [1]. A field that uses several methods of different modalities is the non-destructive testing. For the inspection of composite materials there is no single method that works effectively, therefore for such materials a comprehensive evaluation by different NDT methods is used, in this case it is the image compilation that can be helpful.

BODY

The purpose of nondestructive testing is to check the reliability of the basic operating properties and parameters of an object or its elements. The main advantage of this approach is the possibility of control without dismantling, stopping the work process.

The selection of NDT methods depends on the application and the material to be inspected. The following inspection methods are classified: magnetic, electrical, eddy current, radio wave, optical, radiation, acoustic, permeation, vibroacoustic and visual inspection. For instance, the eddy current method is preferable for detecting defects in aircraft coatings and the ultrasonic method for inspecting pipe thickness [2].

Despite all the advantages of non-destructive testing, it also has disadvantages. The majority of instruments present results visually, which makes such data difficult to automate, especially if several inspection methods are used at the same time. There is also a high risk of false results due to external interference.

Various of these disadvantages can be resolved by the use of image fusion techniques. In most cases, image fusion involves combining information from multiple images to produce a single, more informative image. This improves entropy and signal-to-noise ratios. In order to understand the relevance and value of research into the application of image integration in NDT data processing, it is necessary to analyse existing research.

To begin with, examine the optical method and for this purpose investigate the results of an article authored by Shiwei (2020) [3]. The purpose of this study is to increase the informative value and reduce the influence of stray light in optical

nondestructive testing for detecting defects in parts printed on a 3D printer. Defectoscopy of this inspection object is a relevant area of research indeed. Due to the complex shape of the objects, a deflectometry based method was chosen for imaging. The literature on Moire deflectometry shows that this method produces results similar to interferometry, in which the object under inspection (phase object or mirror surface) is mounted in a collimated beam followed by a pair of transmitting gratings. The author has extracted 3 simple methods of combining: maximal difference detection, maximal brightness detection and morphological combining. A new defect detection algorithm has been proposed in this paper, the algorithm is divided into a preliminary and a subsequent process. In this publication, the author decided to focus on the pre-processing which contained image complexing and thresholding for binary mapping. During the experiments, the accuracy of the proposed algorithm was calculated amounted for 86 per cent. Despite the accuracy of the proposed algorithm, this study does not provide comparisons with algorithms used in practice. For this reason, there is no direct advantage offered by this method.

Thirunavukkarasu (2012) examines methods of increasing the information value of images by eddy current testing [4]. Eddy current testing is an important issue for detection of subsurface defects. This study highlights that non-destructive testing method has disadvantages such as low pixel resolution and poor signal-to-noise ratio. The authors demonstrate an increase in these indicators when using image fusion. Author used 4 methods for image fusion: Laplacian pyramid decomposition, wavelet transform, Bayesian, principal components analysis based fusion. As metrics for this research were chosen Signal-to-Noise (SNR) and entropy. Images for the experiment were generated programmatically. Together, these experiments indicate that image fusion increases informativity of the resulting image. The best result was shown by Bayesian based fusion, because this method has the highest SNR and entropy. Despite the positive results that were shown in this article, it has some disadvantages. A weakness with the author's results, however, is that obsolete metrics were used. The findings may have been more applicable if authors used methods such as mutual information or conditional entropy, which are correlates of informativity [5]. Moreover, the images were taken by program, but not from a real environment.

Examine the example of multimodal complexity provided in Gros's (2000) article. The difficulty with composite material is that there is no single inspection method with which it is possible to recognise defects. To solve the problem of multimodal image processing of the inspection object the author proposes methods of image complexing. In this study, image fusion techniques such as Bayesian analysis, Daubechie wavelet, controlled pyramidal transform wavelet and multi-resolution mosaic technique were used. The fusion of two images from two different non-destructive testing systems was carried out in order to obtain additional information through data transfer from the input images and as to improve the reliability of the non-destructive testing [6]. The authors concluded in the study that the image fusion methods for use in non-destructive testing require further development. This is due to different modality of images, that is, with significant differences in the nature of the images. The authors suggest that it is possible to develop pre-processing algorithms different for each non-destructive testing method, which will solve the identified problems. The authors did not propose

a solution to this problem.

Among the widely used non-destructive testing methods, ultrasonic testing occupies a special place because of its broad range of application possibilities. Current research (Pilikos, 2021) is focused on analysing the possibility of using image complexing for ultrasonic nondestructive testing tasks. Ultrasonic nondestructive testing visualises information about the acoustic properties of an object under test by emitting waves into it and recording their effects using arrays of ultrasonic transducers. The author suggests imaging using different insonation paths, for instance by placing transducers in different locations or if strong reflectors are known a priori within the medium. In this way, images will be obtained reflecting different geometric information about the scatterers. The author proposes a new deep convolutional neural network (DCNN) architecture to combine raw data from multiple insonation pathways into a segmentation map. The results show that the mean cross entropy values of the image obtained from the proposed architecture are 0.003 as compared to 0.398 for the traditional image fusion method. Therefore, there is a significant drop in entropy, which is a correlate of the increase in image informativeness [7]. However, there is reason to doubt the results obtained, as it is an open question why the author chose this particular metric and no others were used for comparison. Also, it is not known with which classical methods of fusion the researcher compared the proposed neural network architecture. Without this information, there is no possibility to verify these results.

CONCLUSION

After reviewing the literature, it can be concluded that no solution has yet been proposed that is ready for practical use. This is due to a number of problems associated with the multimodality of different NDT methods. The authors have demonstrated current techniques for obtaining images that can be used in fusion. In connection with the development of new machine learning technologies, the informativity metrics used are obsolete. However, the use of classical methods of non-destructive testing quality assessment is a relevant idea, as this type of metrics is the most objective.

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