1) Title of the paper

Development of Visual Inspection System based on Vector Analysis Technique

2) Names and affiliations of the Authors

Masatake Sakuma, Katsumi Kubo, Shigeru Kanemoto, *Takashi Butsuen,
**Yoshifuru Saito, ***Kiyoshi Horii
Toshiba Corp., *Toshiba Engineering Corp.,
**Hosei University, ***Shirayuri College

3) Person to be contacted

Masatake Sakuma
Shin-Sugita cho 8, Isogo-ku, Yokohama, Kanagawa, JAPAN. 235-8523
Phone:+81-45-770-2373/Fax.:+81-45-770-2313
E-mail address:masatake.sakuma@toshiba.co.jp

4) Answers to the questions

a) What is the original contribution of this work?

The potential availability of the new technique based on vector representation of digital image was investigated through welding defect type recognition problem.

b) Why should this contribution be considered important?

The technique proposed in this paper can widely be applied to various kinds of edge extraction or shape recognition in ambiguous pattern on rough texture.

Abstract

The present paper proposes a new concept of image processing method based on vector representation for visual inspection test. The method gives flexible and useful algorithms for detection and identification of small defect in noisy images.

Visual inspection test is widely used for structure integrity check in various phases of plant construction and maintenance. Most of current visual inspection depends on expert's skills since automated small defect detection from rough surface was difficult for conventional image processing techniques. However, indirect visual inspection often cause difficulties in identification of defects even for trained inspector due to the effect of reflection and shade on welded surface condition[1].

This paper describes the method to detect defects and extract their profiles based on digital 2D image using vector field theory, for the development of automated visual inspection system to welded rough surface of the structures. The developed algorithm is aiming at the automation of the visual inspection using digital image processing technique in order to maintain the objectivity of the visual inspection quality.

Vector representation of image is defined by regarding intensity of each pixel as a component of vector or scholar potential[2][3]. According to vector field theory, rotation vector $R_{i,j}$ at pixel (i,j), one of such vector analysis, can be expressed as follows($I_{i,j}$: intensity at pixel (i,j)):

$R_{i,j}=((I_{i,j+1} - I_{i,j-1})/2, -(I_{i+1,j} - I_{i-1,j})/2)$

An example result of rotation vector calculation for a magnified defect image is shown in Figure 1. It is easy to recognize from the figure that the direction of the rotation vector is along with the edge of the defect on welded surface, and distribute around the edge in clockwise direction to the center of defect. According to these characteristics, it is possible to extract shape information of the defect by connecting neighboring pixels, in which direction of the vector is similar. Furthermore, edge connection algorithm, which only refers to the vector direction information, makes it possible to extract outline of defect shape independent of vector length.

We have applied the algorithm described above for pre-processing and performed extraction and identification of defect candidate in the welded surface images. The extraction algorithm include thinning, segmenting and connecting outline

pixels considering vector direction similarity in the neighboring pixels. In the identification algorithm, three measures were introduced to distinguish defect types (line crack, porosity and noise). First measure is cross section of the defect, second one is complexity (the square of outline length divided by cross section of the defect) and third one is the vector direction profile. Vector direction profile is defined as the distribution of the vector direction (=angle) for the outline pixels of the defect. The results for acquired images of welded surface with defects were plotted in three-dimensional space, each axis of which corresponds to the measure. It was confirmed that the distribution was separated in the space depending on the defect type and they were properly identified.

The potential availability of the new technique based on vector representation of digital image was investigated through welding defect type recognition problem. The technique proposed in this paper can be widely applied to various kinds of edge extraction or shape recognition in ambiguous boundary on rough texture.

Reference

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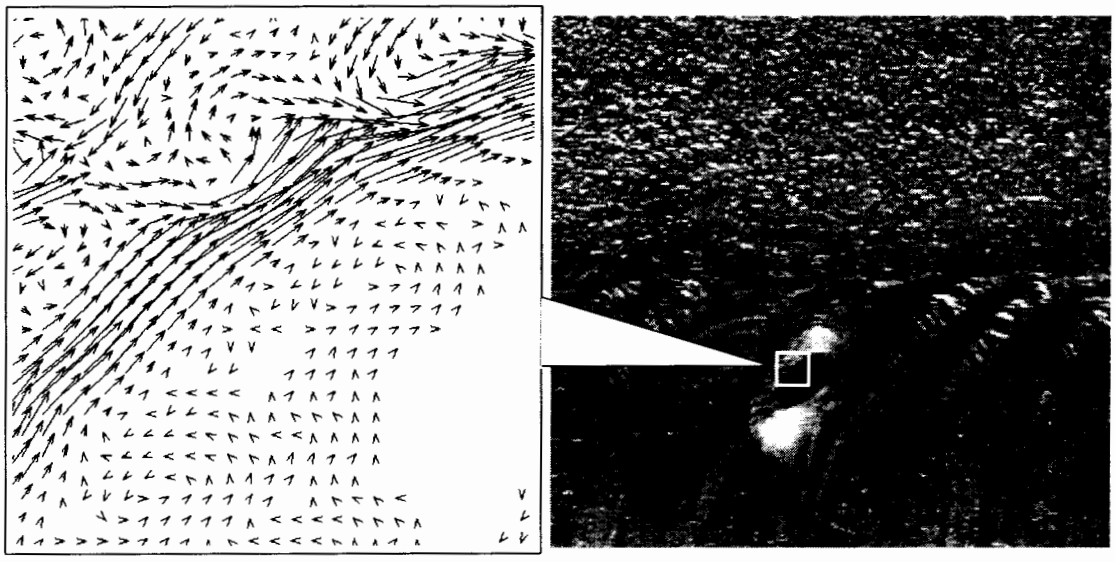

Figure 1 : Rotation vector representation of welded surface image around defect