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A Review on Inspection of welding defects using Segmentation Techniques

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Abstract— The inspection of welds plays a crucial role in world wide industrialized markets. It is needed for assuring safety and consistency in several industrial sectors. The special types of vision inspection systems are used to defeat the crisis such as inaccuracy in images, non-uniformed illumination, noise and deficient contrast, confusion of defects in same spot at surface. Non-destructive testing (NDT) is a technique used in science and industry to evaluate the properties of a material without causing harm. This review addresses the comparative study of snake model with GVF and level set method of the segmentation techniques used in inspection of welding defects.

Index Terms— Segmentation, Snake model, GVF, level set

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1 Introduction

Industrial radiography is an eminent technique for the detection and evaluation of discontinuities or defects such as cracks, porosity & foreign inclusions found in welded joints. Computer vision is a key factor for the completion of total quality within different processes in industrial automation. Segmentation processing is a critical step in radiographic image analysis of weld defect. It consists mainly on detecting and visualizing the common boundaries of distinct weld defect in the image. Radiographic testing (RT) usually is appropriate for testing welded joints that can be accessed from both sides, with the exception of double-wall signal image techniques used on some pipe. The process that allows automated computer vision is known as Automatic Visual Inspection (AVI) and its objective is to determine whether a product lies inside or outside the range of acceptance for a determined manufacturing process. Segmentation is one of the initial stages within the AVI process. Its application allows the initial separation of regions of interest which are subsequently classified. In order to improve product quality AVI system must meet the efficiency and speed.

1.1 Segmentation Techniques

One of the trained domains in industry is weld inspection which deals with analyzing the inside or outside of the weld to trace any defects which may cause failure in the system. There are many different welding methods that depend on the accuracy of the process; the weld designer chooses the one which is appropriate. The popular approaches of image segmentation are the active contour models. The models snake model and level set methods are used in edge detection, shape modeling and motion tracking.

2. Snake Model

The active contour/snake model is one of the successful models in image segmentation. It consists of developing a contour in images to the boundaries of objects. Active contours are extensively used in the field of digital image processing to find the contour of an object by forming a snake around its boundary. It involves running a low level image processing task such as canny edge detection which is mostly unsuccessful because often the edge is not continuous, i.e. the image might be noisy or there might be concavities present in the image. Hence Active Contours are an advanced way of image segmentation as it adds certain properties to the image before performing segmentation which makes the process of locating the boundary comparatively easier.

The only difficulty of this model is the existence of local minima in the active contour energy, which makes the initial deduction serious to get satisfactory results. Active contours or snakes are used widely for image segmentation and processing applications, mainly to locate object boundaries. Active contours are regarded as capable and dynamically researched model-based approach to computer assisted medical image analysis.

2.1. *Original Snake Model by Kass*

The concept of active contours was introduced by Kass. The energy functional for calculating the snake energy is

$$E_{snake} = E_{internal} + E_{external} + E_{constraint}$$

The snake energy has three terms. The first term E_{int} is the internal energy of the snake,the second term E_{ext} denotes the image forces, the final term Econ gives rise to external constraint forces. The summation of the image forces E_{img} and the external constraint forces Econ is the external snake forces, denoted by E_{ext}.

Internal Energy (E_{int}) depends on the basic properties of the curve and is the sum of elastic energy and bending energy

E 1

$$E_{snake} = E_{internal} + E_{external} + E_{constraint}$$

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External energy (E_{ext}) of the contour is resulting from the image so that it takes on its minor values at boundaries. A function $E_{image}(x,y)$ is defined to take the smaller values at the features of interest, such as boundaries.

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The major difficulty encountered in the traditional snake model was that the early contour must in general, be close to the true boundary or else it will expect an erroneous result. It is sensitive to initial curve position and initial curve shape and doesn't have the capability of changing with topology. So the external force called gradient vector flow (GVF) for active contour model is computed as a diffusion of the gradient vectors of a gray-level or binary edge map derived from the image. The resultant field has a large capture range and forces active contours into concave regions, hence solving both the problems. Since the external forces cannot be written as the negative gradient of a potential function, GVF snake is different from all other snake models used before. The major advantages of GVF snake over the other snake models are its intensity for initialization and its ability to move into concavities. The GVF snake can be initialized far from the boundary since it has a large capture range. And unlike pressure forces, the GVF snake does not require prior knowledge about when to shrink or expand towards the boundary.

2.2. Gradient Vector Flow Model (GVF)

The gradient vector flow snake is used in order to increase the capture range and improve the snakes ability to move into boundary concavities. The capture range of the original snake is generally limited to the vicinity of the desired contour. Furthermore the original snake has problems with moving into concave regions e.g. moving into the concave region of an U-shaped object, the gradient vector flow snake handles these problems by introducing a new external force. By minimizing an energy function we can derive a new vector field by using this external. We call these vector fields as gradient vector flow fields.

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3. Level set Method

The level set method was introduced by Osher and Sethian [13]. The level set method is a numerical and theoretical tool for propagating interfaces. The fundamental idea is to start with a closed curve in 2D or a surface in 3D and let the curve to move perpendicular to itself at a given speed. In image processing the level set method is most often used as a segmentation tool through transmission of a contour by using the properties of the image. The first applications was to detect edges in an image [14], but in more modern applications textures, shapes, colors etc can be detected. In the level set method, an interface C is represented implicitly as a level set of a function φ is called level set function, of higher dimension.

Level set method is a technique to denote active contours [13][14]. For a certain image *u0*, we can generate a level set function φ(*x,y*) with the equal size of the image *u0* to express the contour. The contour is defined as the zero level set of the function φ:

$$C = \{(x, y) \mid \varphi(x, y) = 0\}.$$

The inside and outside region of the curve are clearly defined as:

$$\begin{cases} \varphi(x,y) > 0 & \text{inside the contour} \\ \varphi(x,y) = 0 & \text{contour} \\ \varphi(x,y) < 0 & \text{outside the contour} \end{cases}$$

By changing the φ values, some regions that are originally negative will turn into positive, and vice versa. Therefore, the contour will vary according to the update of the level set function as in figure 1.

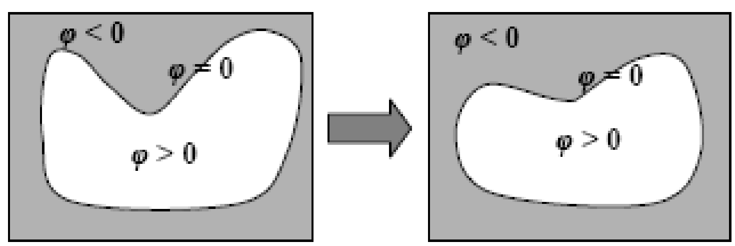

Figure 1. Illustrations of the level set method and the contour change

The active contour by level set method can easily represent complicated contour changes and can easily know whether a point is inside or outside the contour by checking its φ value.

Creation of a speed function is critical in applying the level set method to radiographic image segmentation. When segmenting radiographic images with classical level set methods, the propagating front may not be able to capture the real boundaries. The enhanced speed function can tackle the segmenting problem in radiographic images.

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This method overcomes the drawbacks of snake model. This method is used to hold the composite topological changes automatically. Based on an postulation the level set function is or close to a signed distance function (SDF). Simple numerical schemes based on fixed differences are applied to compute gradient. Total variation Diminishing (TVD), Runge Kutta (RK) methods are used to attain higher order accuracy.

3.1 Inspection of images using level set method

The level set method is used to detect the boundary of weld defect. In this system, the method of level set without re - initialization to radiographic images and done the comparison between different methods.

First the level set method without re-initialization is applied and the time step of about 4-6 without affecting the stability of the algorithm and the execution time is reduced. The contour of the image is developed. During the evolution of level set function the topology has changed 124 iterations. Double- well potential is used for distance regularization. The edges are obtained at 310 iterations and an execution time of 10.156553 sec, and satisfactory results were obtained. The double-well potential for distance regularization provides enhanced results than the single well potential to identify the boundary of weld defect.

4 Results and Discussion

The application of GVF to the traditional active contour model improves the quality and correctness of image segmentation. But the difficulty was that of small captured image. The major problem with original snake model is small range of capture image. So that the external factor GVF is added with snake model to increase the range of capture image. GVF model provides a combined way of treating illustration problems that were tilled now treated in a different way. However, continued development, improvement and alteration of these methods are an important research area with the goal of producing robotic, exact and strong segmentation models.

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