Radial Basis Function Support Vector Machine Based Soft-Magnetic Ring Core Inspection

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Abstract. A Soft-magnetic ring cores (SMRC) inspection method using radial basis function support vector machine (RBFSVM) was developed. To gain the effective edge character of the SMRC, a sequence of image edge detection algorithms was developed. After edge was detected, feature vector was extracted. Subsequently, principal component analysis (PCA) is applied to reduce the dimension of the feature vector. Finally, RBFSVM is used for classification of SMRC, whose best accuracy in experiments is 97%.

Keywords: soft-magnetic ring core (SMRC), radial basis function support vector machine (RBFSVM), edge detection, principal component analysis (PCA).

1 Introduction

Soft-magnetic ring cores (SMRC) are a vital part of electrical appliances such as chokes, in-line filters, voltage and current transformers [1]. To obtain the desired production quality, its dimension should be inspected carefully because high temperature agglomeration lead to distortion. In the soft-magnetic materials industry, the quality evaluation of SMRC is still performed manually by trained inspectors, which is tedious, laborious, and costly, and is easily influenced by physiological factors, thus inducing subjective and inconsistent evaluation results. Increased demand of SMRC have necessitated the automated quality evaluation of SMRC.

Utilize machine vision technique to substitute human's eyes, to take pictures of SMRC and to inspect the product, which greatly enhance the product quality and the production efficiency. Machine vision is that the equipment with computer is used to realize human's vision function, i.e. computer is used to recognize the object things. With the ceaseless development of machine vision technique, human gradually applied this technique to many aspects of manufacture and life [2], [3], [4].

2 Materials and Methods

The samples of soft-magnetic ring core were often categorised into five quality levels by the qualified inspection personnel in the company, i.e., reject oversize, acceptable oversize, precision size, acceptable undersize and reject undersize. The overall sequence of digital image processing algorithms for classification of SMRC mainly

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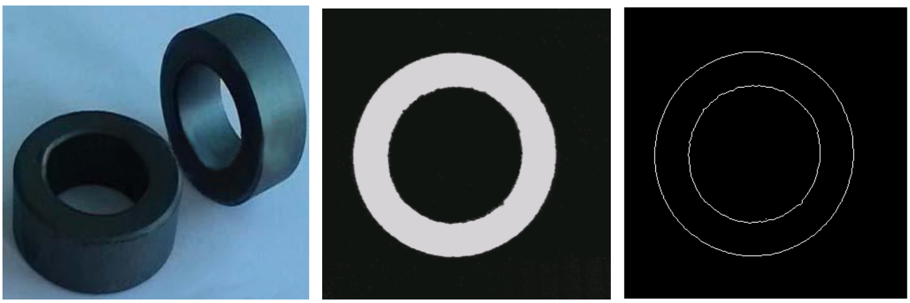
include five steps: a, image acquisition; b, edge detection; c, feature vector extraction; d, reduction dimension by PCA; e, RBFSVM classification.

2.1 Edge Detection

To get the edge of SMRC, a gradient-based detection approach was developed, which includes three steps, i.e., edge detection, morphological dilation and edge slenderization. For the SMRC image that differs greatly in contrast from the background, the Roberts operator was applied to detect the edge of SMRC. To eliminate the gaps in the edges, morphological dilation was implemented to the edge image. Then the edge was slenderized to one pixel width. The result of edge extraction was shown in Fig.1.



a. SMRC b. the acquired image c. the edge of SMRC

Fig. 1. Edge extraction

2.2 Feature Vector Extraction

To get the centre of SMRC, a supposed center (x_0, y_0) was put forward. The (xa_i, ya_i) was supposed to be the point of the outer edge and m is the point quantity of the outer edge. The (xb_j, yb_j) was supposed to be the point of the inner edge and n is the point quantity of the inner edge. The ra and rb was the desired outer radius and inner radius respectively of SMRC. The da_i and db_j was the distance from the outer edge point and the inner edge point respectively to the supposed centre.

The optimal centre of SMRC is the one that minimizes the following formula,

$$F = \sum_{i=1}^{m} da_i^{\ 2} + \sum_{j=1}^{n} db_j^{\ 2} \ . \tag{1}$$

The centre can be obtained by solving a quadratic equation extremum problem. Let

$$\begin{cases} \dfrac{\partial F}{\partial x_0} = \sum_{i=1}^{m} 2(x_0 - xa_i) + \sum_{j=1}^{n} 2(x_0 - xb_j) = 0 \\ \dfrac{\partial F}{\partial y_0} = \sum_{i=1}^{m} 2(y_0 - ya_i) + \sum_{j=1}^{n} 2(y_0 - yb_j) = 0 \end{cases} . \tag{2}$$