Detection of surface defects and irregularities of ferrites*

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Ferrites are ceramic magnetic materials made of oxide powders. Ferrite cores are manufactured by compacting and sintering these powders, and by grinding some surfaces to required dimensions. The aim of the paper is a presentation of the methods of detection and measurement of certain surface irregularities which emerge in the manufacturing process. These are classified as chippings, cracks and ragged edges.

It must be stressed that ferrite is a nearly black material, which makes visual inspection difficult. Some classes of defects appear similar; nevertheless, acceptable accuracy of their classification has been attained. Although the presented study concerns ferrites, the same methodology can be used to investigate surface defects in other materials.

The monochromatic images of the irregularities of interest are acquired by the system consisting of the optical setup, digital camera, and the computer. Subsequently these images are analyzed by a specialized software. Among the algorithms used there are:

1. Morphological defect detector and morphological pyramid.
2. Feature generator.
3. K-nearest neighbours classifier.

The **morphological detector** is used in order to obtain the masks of the areas in the image which correspond to defects detected. Usually defects manifest themselves in the image by some change of brightness and may have an arbitrary shape and size, which makes them more difficult to detect. A defect detector should detect all kinds of defects and at the same time should be insensitive to noise, that is it should not classify noisy pixels as belonging to defect areas. Morphological defect detector can effectively detect arbitrary defects which are not significantly greater than the structuring elements used in the morphological operations. For detection of bigger defects a morphological pyramid is used. In this case the structuring elements are kept of the same size, but the image is reduced. In this way the relative size of the structuring elements increases; however, because of the reduction of the size of the image the defects are detected in a considerably shorter time.

The **feature generator** is used for assigning numerical values to the defects detected by the morphological pyramid. The features used were selected from a large number of possible statistical textural measures, based on about $100,000$ examples of pixels belonging to various irregularities as well as to regular surfaces of the ferrite cores.

The **k-nearest neighbours classifier** classifies the defects as belonging to one of the following classes: chipping of the edge, chipping in the interior part of a certain surface, crack, no defect, background. Further clustering of defective pixels allows one to decide whether the chipping of the edge is in fact a chipping or a ragged edge.

The paper presents a number of experimentally obtained results of defect detection and classification. The two-stage classifier according to [1, 2] has been used in classification as well as in feature selection. It applies a simple 1-nearest neighbour rule if the complex, fuzzy k-nearest neighbours rule is not necessary, to speed up the recognition process.

References

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