Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 100 (2015) 492 – 498

Procedia Engineering

www.elsevier.com/locate/procedia

25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM 2014

Industrial Image Processing Using Fuzzy-Logic

Catalin Gheorghe Amza*, Dumitru Titi Cicic

University Politehnica of Bucharest, Splaiul Independentei 313, sector 6, Romania, 060042

Abstract

This paper concerns with the utilization of artificial intelligence borrowed techniques such as fuzzy logic for the automatic analysis of X-ray images of industrial products for defect detection. An original two stages algorithm is presented based on the feature analysis of the radiographic images obtained from the inspected product. Each object in the image is analyzed using fuzzy logic techniques. The first stage takes an automatic decision whether the current object can be classified as a defect from the geometrical point of view and the second stage takes the final decision by using “logical” criteria that is dependent on the product at hand and its quality requirements.

Peer-review under responsibility of DAAAM International Vienna

Keywords: fuzzy logic; non-destructive testing; image processing

1. Introduction

Image processing has become an integrated part of modern industrial manufacturing systems, mostly used in a variety of manual, semi- and automatic inspection processes. Such an inspection system usually acquire an image of the product that needs to be checked for quality conformance and subsequently that image is analysed either by human operators or automatically by a computer via specific image processing techniques. Whereas such a system is used for detection of metallic or non-metallic contaminants (e.g. glass, bones and stones, for detection of defects of raw or prepared meat, fish, cooked products, packaged products, vessels, tins, conformance of welds and castings, etc), it usually involves some means of acquiring one or more images of the inspected product. The most important type of image used in commercial inspection systems is the radiographic image [1], [2]. Depending on the quality of the acquired X-ray images or on the performance of the actual X-ray acquisition system and the X-ray absorption

* Corresponding author. Tel.: +40 744 500 803; fax: +40 21 402 9541.
E-mail address: acata1@camis.pub.ro

Peer-review under responsibility of DAAAM International Vienna
doi:10.1016/j.proeng.2015.01.404

coefficient of the inspected product, one can use various image processing techniques in order to detect possible defects. Such a method is based on the following stages:

General imaging inspection process
Step 1 **Acquire** the image or images of the inspected product
Step 2 **Image pre-processing** of the resulting image or images
Step 3 **Image segmentation**
Step 4 **Object and feature extraction** for the obtained segmented image
Step 5 **Detection of possible faults or defects** of the product
Step 6 Final product **acceptance** or **rejectance**

Image acquisition is having the means of generation of X-ray images of the inspected product and means of transmitting them to a computer. Image pre-processing implies the use of techniques for enhancing the radiographic obtained images for intermediate level image processing (contrast enhancement, background removal, noise removal, etc.) [3], [4]. Image segmentation is the most important stage of such an automated image processing system. It is simply a problem of partitioning the image into several classes of objects. Most segmentation methods currently rely on simple thresholding algorithms [5], [6], [7]. Due to the fact that usually, the inspected product has different materials with various thickness that is a function of a random variable, simple thresholding algorithms cannot be applied for segmentation of such X-ray images into objects [1], [8]; there are also various methods that are using artificial intelligence techniques such as back propagation neural networks, Kohonen neural networks or Hopfield neural networks [9], [10], [11], [12], [13]. Depending on the acquired radiographic image, the results of the segmentation should be optimum (meaning that the X-ray image is partitioned into meaningful objects for their consequent analysis). At the object and feature extraction step, the method should be able to extract and to compute some features for each object from the segmented image; the feature extraction process is highly dependent on the inspected products; if one seeks to inspect welds, then it looks for cracks, gas inclusions and then the features extracted from the images can be based on their geometrical properties, on the spatial properties or on their grey-level properties as compared to the background; if one looks to find contaminants in deboned chicken breast meat, then it looks for bone fragments that are usually very small and of a particular shape (round) hence one can only extract geometrical features from the segmented image. The final step relies on the objects and its features extracted previously. It is a classification problem or in more general terms a pattern recognition (PR) problem [14]. The method is an issue of classifying each object as being normal product or a defect. Once the features are extracted from an object, the simplest way is to compare them with the information already stocked within a knowledge database (or a simple look-up table). The knowledge base is usually designed using expert observations. Sample images are analysed by human experts and the information is saved in a useful format in an expert database. The methodology is presented in Figure 1.

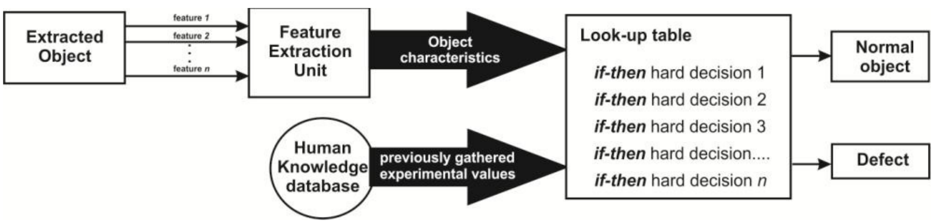

Fig. 1. Classical approach to object classification.

The main disadvantage of this approach is that it uses predefined hard *if-then* decision. The implemented look-up table consists of already stored patterns gathered thorough experiments and based on human knowledge. Small variations from those already stored patterns will render unreliable results. For instance, at this later stage of the inspection system, noise can appear in the feature extraction process, therefore altering a feature's values. This is either the result of poor segmentation or the results of image corruption during the image acquisition stage or due to transmission over cables of video signals often affected by the presence of electromagnetic fields, or bad shielding of cables. This paper concerns with step 5 of the image-processing system – the detection of possible faults or