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Ultra Sonic Image Interpretation for Non-Destructive Testing

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Abstract

For interpretation of ultra sonic images an image interpretation system based on case based reasoning is proposed. We describe the case representation and the case based reasoning process.

1 Introduction

Model-based or rule-based methods are commonly used for image interpretation. These methods require to have generalized knowledge about the objects to be interpreted. Various applications [1][2] showed that often this knowledge is lacking. Even once starts out with the automation of a new process or application then it needs time or a lot of investigations to built up this generalized knowledge about the objects. Therefore we propose a sytem based on case-based reasoning [3]. As application domain we chose ultra sonic image interpretation for non-destructive testing.

2 Case Representation

A single image, following called case, is represented by objects, their attributes (e.g. graylevel = light, grey, blaick; size = large, middle and small) and the spatial relations (e.g. left_behind, right a.s.o.) between the objects. That gives a structural representation for an image represented as an image graph. Images of that kind are for example ultra sonic images for defect classification shown in Figure 1. The images were aquired by the SAFT ultra sonic system [6]. Thresholding technique is used for binarization (s. Fig. 2), preprocessing is done by using morphological operators like dilation and erosion (s. Fig. 3) and afterwards the objects are labeled by the line coincidence method [8]. Symbolic transformation of the numeric information of an object is done with the help of a functional model for space [7, size and greylevel [8]. The symbolic description of the image is used since it is natural to an operator to describe images in that terms.

3 Case Based Reasoning Process

The basis for the development of our system is a set of cases $CB = \{G_1, G_2, ..., G_i, ..., G_n\}$, each case is a 3-Tupel $G_i = (N, p, q)$, which is a structural symbolic representation of an image, and a similarity measure δ for structural representations. For the current image an image graph is extracted by image analysis (s. Chap. 2). This structure is used for indexing . The interpretation of a current image S is done by case comparision: Given an image $S = (N_s, p_s, q_s)$, find a case G_m in the case base CB which is most similar to the current image. Output the case G_m and the stored solution (e.g. in our case,the defect name).

4 Similarity Determination

For similarity determination between our image graphs we chose part isomorphism [4]. In order to handle the unsharp attributes and distortion in a graph representation we relaxed the required correspondence of attribute assignments of nodes and edges in such a way that we introduce ranges of tolerances according to the semantic terms [5].

5 Organization of Case Base

If we have many cases in case base then it can becomes very time consuming to find the closest case to an actual case . Therefore, we have to organize our case base in such a way that it is possible to find the closest case without examing all existing cases for similarity in case base. On way to impose constraints on retrieval is to index cases using concept hierarchy. Elements in the case base are representations between graphs. As an important relation between these graphs we have considered similarity based on part isomorphism . Because of this characteristic it is possible to organize the case base as directed graph.
For the nodes in this new hypergraph, we introduce a new attribute it is called "defect_type_description". To this attribute are assigned the names of the various defect categories and classes, e.g. voluminous defect,

which will be learned interactivly with the operator during the usage of the system.

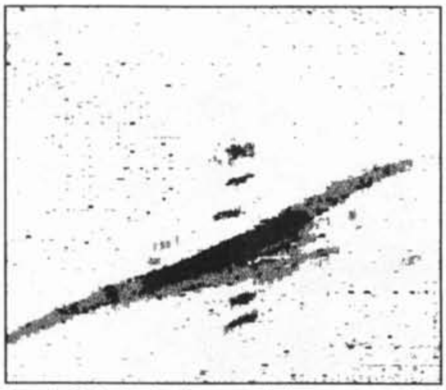

Fig. 1 Original ultra sonic image (crack)

Fig. 2 Binaray Image

Fig. 3 Image after preprocessing

6 Learning

At the beginning of the learning process the case base can be an empty set. Based on an available set of cases we construct an initial hyper graph for case base. But we should note that for each group of graphs that is approximately isomorphic, the first occured image graph is stored in the case base. Accidental, this could be a „bed" image graph. Therfore, it is better to calculate of every instance and each new instance of a group a prototype and store this one in case base.

Another type of learning takes place when the system tells us no similar case is in case base. If no case in case base is similar to the actual case that could mean this situation has never happend before. In that case the new case has to be stored in case base together with the description for the defect type given by the expert. But before this is done, the system has to check if the determined similarity between cases in case base and the actual case is sufficient enough. If the system finds out that this case happens the similarity measure gets updated according to the new case.

7 Evaluation of the System

Accuracy (A = (number of right recall / number of samples) * 100) was calculated based on 100 samples. The information „no similar case" was only taken as an error if there was a similar case in case base but the system could not call it based on the chosen similarity. Among this data set were 5 cases which are not related to any case in case base. Accuracy was 95%.

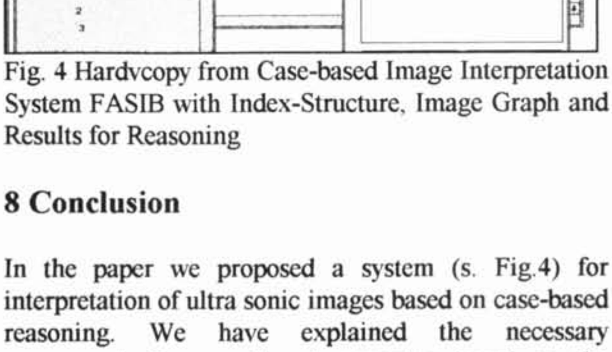

Fig. 4 Hardvcopy from Case-based Image Interpretation System FASIB with Index-Structure, Image Graph and Results for Reasoning

8 Conclusion

In the paper we proposed a system (s. Fig.4) for interpretation of ultra sonic images based on case-based reasoning. We have explained the necessary components for case based reasoning based on the example of ultra sonic images. The evaluation of the system showed that the method is a good alternative to other methods like model based or rule based systems even if there is no generalized knowledge available . It can learn cases and incooperate cases in the existing case base in an efficient way. The system is realized on PC-486 in C++ language.

For more information about the theoretical details and the algorithm used for that system we refer the interested reader to [5].

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