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Intelligent Image Processing Framework

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Extended Abstract

We have developed a generic and flexible image processing framework that can be easily applied to a multitude of image-based product quality inspection tasks.

Automation of product quality inspection systems is essential for achieving a high productivity in the manufacturing industry. Vision based inspection systems can be a cost effective solution if they can be developed fast and provide robust results. Such systems consist of one or more cameras that acquire images of the product that needs to be inspected, and then process this images in order to assess the presence or absence of defects.

In a classical approach the image processing consists in applying image transformations, which produce a value for every pixel in the image. These values are called features and each of it is subsequently compared to, most of the times, one threshold. Based on the results of these comparisons a hard decision is generated: the product is good or bad.

FMTC has developed a multi-stage image processing framework that uses advanced machine learning algorithms. These algorithms can build more complex defect models making their detection and identification more accurate and robust.

The first stage operates at pixel level and its goal is to segment the image in objects of interest, called BLOBs. The BLOBs are analyzed in a second stage to decide which ones are indicating product defects and which ones are not. At this stage a probability that the BLOBs belongs to a certain class, defect or no defect, is generated. In a third stage the probabilities of the different BLOBs are combined to decide if the image contains a good or a bad product.

A final stage will combine information coming from different viewpoints. These can be obtained either by using several cameras or by rotating the product, or a combination of the two. This is necessary when the products are three dimensional objects that need to be inspected on all sides. In the simplest case the information from different viewpoints can be combined by any kind of voting mechanisms. However, machine learning algorithms can be used in this stage as well, and will lead to improved accuracy of the results.

Each stage consists of an iterative cycle of several steps: labeling, feature extracture, training and testing. First the objects of interest, pixels or blobs corresponding to the defects, are labeled. Features are calculated on the entire image. Examples of features are pixel values, edge detection filters, correlations, fast Fourier transform or wavelet decompositions. The labels and the feature values are used to train the classifiers. Typical examples of classifiers are neural networks, decision trees or random forests. After training, the classifier is tested on an unseen set of images to check its generalization capability.

One important characteristic of the solution is that the accuracy of the classifiers can be tuned according to the requirements of the application. Therefore, it is possible, at any moment to select the trade-off between the false positives and false negatives. The user can decide to give more weight to reducing the number of wrongly accepted products or to reduce the number of falsely rejected products.

On the use cases considered in the project the accuracy of the solution varied greatly, between 80% up to 95%, depending on the completeness of the data set provided and complexity of the fault that had to be recognized. The accuracy was high, above 90%, for inspection of standardized industrial products and it was lower than 90% for inspection of natural products that have a high intrinsic variability.

The framework can accept hyper-spectral images as well. It means that images of the same product taken at different wavelength bands can be used as input. The information present in the different image bands is combined in order to find and identify defects. Hyper-spectral images are widely used in the inspection of biological products but other sectors can benefit from this technique as well.

The framework is an integration of open source software. OpenCV functions are used to calculate the features of the image. Scikit-learn algorithms are used to train the classifiers. Python is used to integrate and automate the entire flow. A simple annotation tools has been developed to label the images.