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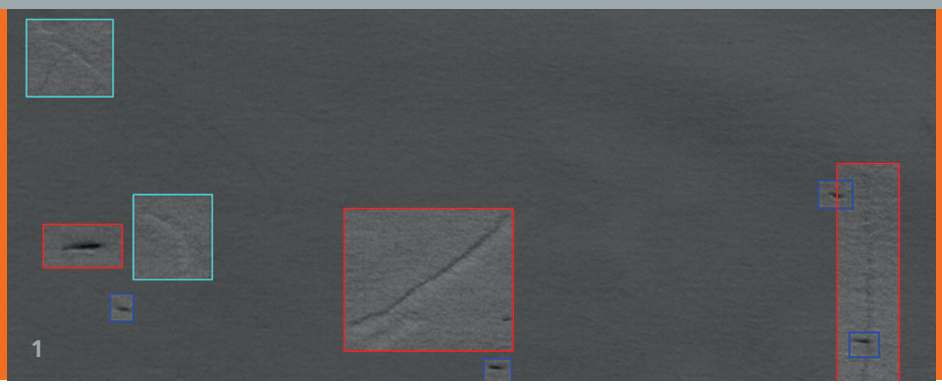

1 *Final result of the defect detection process on an object surface using multiple defect classes*

SURFACE INSPECTION WITH Tool IP

Overview

Tool IP's image processing library offers a wide variety of mathematically founded operations. All available algorithms have been developed in C++ and can be combined in a flexible way to create image processing solutions fulfilling customer-based requirements.

Functionality

Tool IP allows for building complete solutions for complex image analysis tasks in a very intuitive way. It comes with an integrated image processing library. Especially for software developers Tool IP offers the possibility of building tailored solutions. Basic knowledge of image processing is advantageous.

In Tool IP solutions are displayed as graph-like structures. Each node represents an algorithmic component whereas the edges describe the data flow. By drag and drop new algorithms from the left side menu can be included. The resulting image processing solution can be embedded into customer applications.

Benefits

- Platform-independent using an XML-format for solutions
- Highly modular and reusable by representing solutions as additional operations
- Intuitive operability allowing for rapid prototyping and system integration
- Integration of Tool IP solutions into customer applications is possible

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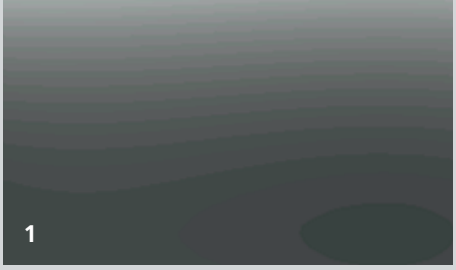
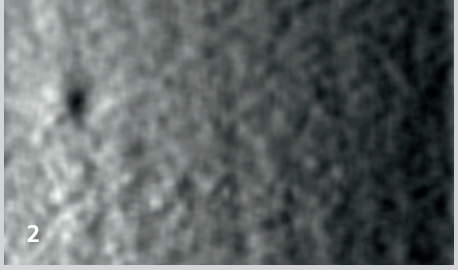

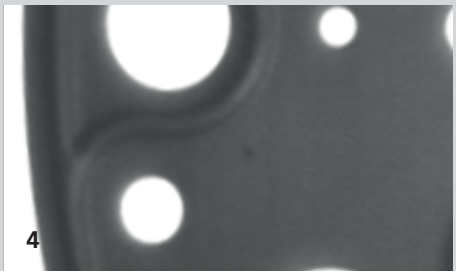
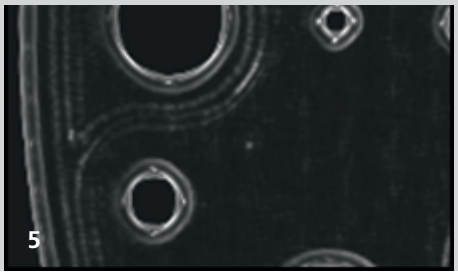
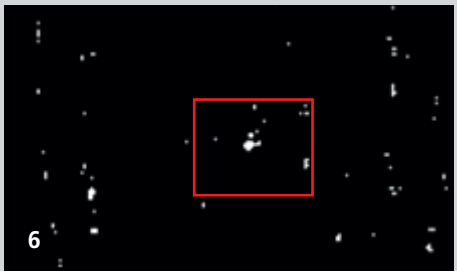

Image processing with ToolIP – library modules

ToolIP contains the following modules, each including multiple image processing algorithms:

Basic Image Handling
A rich set of image formats and color spaces is supported. There are many operations that allow adapting the orientation, resolution, coordinate system etc. of the image data to the specific application.

Image Denoising and Enhancement
The library includes a variety of useful filtering operations including linear filters, morphology filters, ranking filters, and several adaptive anisotropic filtering approaches.

Edge Detection
It provides many possibilities including gradient calculation with several masks, edge detection with Canny's detector and ridge detection using the Hessian matrix. Furthermore, line structures in images can be detected using the Hough transform.

Object Detection
Known objects can be easily detected by using templates. Gradient based object models and similarity measures derived from the displacement histogram are provided.

Image Registration
The library offers robust grey-value-based matching via maximization of statistical similarity measures derived from the joint grey level distribution.

Segmentation
Besides basic thresholding, Otsu's method, and the Mardia and Hainsworth method, also automatic adaptive thresholding via maximized mutual information and custom thresholding derived from the image histogram are supported. Apart from image gray-values, many other local features are available for the segmentation process.

Labeling
Working with labeled objects offers a high degree of flexibility. Mapping features onto single segmented objects allows for selection and classification of objects with respect to their characteristic region features.

Region Features
Each identified object can be characterized using a variety of image features, like average, variance, entropy, texture descriptors (e. g. Haralick, Local Binary Pattern) or geometry descriptors. This is useful for analyzing objects with highly complex characteristics.

Classification
Several classification algorithms such as linear discriminant, Mahalanobis distance classifiers, SVM and Gaussian mixture models, are provided to automatically distinguish objects belonging to different classes.

Clustering
Automatic grouping of objects is supported. Beside the KMeans algorithm also more sophisticated approaches can be realized using operators from the linear algebra module.

Matrix Operations
In addition to standard image processing methods, also linear algebra operations are available. These operations are especially useful for developing advanced pattern recognition algorithms. Supported operations include the SVD, the QR-decomposition, matrix inversion, the computation of eigenvalues and eigenvectors as well as algorithms for PCA and ICA.

Camera interface
An interface for Prosilica cameras is available allowing for image analysis inline. This way rapid prototyping can be carried out under real-time conditions. Other cameras can be supported on request.

Third party libraries
A number of useful algorithms, such as an optical character recognition method (OCR) and a QR-code reader, have been integrated from the third party libraries ITK and OpenCV.

1–3 *Detection of a dent on an unpainted car body (original image, after curve fitting, covariance)*

4–6 *Detection of a defect on a gasket (original image, application of a region feature, actual defect)*