Zero Error with Automated Crack Inspection

Richard SÖHNCHEN, Automation W+R GmbH, Munich, Germany

The importance of automatic crack inspection is constantly rising in all industrial areas due to the zero error requirements. In particular the automotive industry continuously raises the quality ability demands for their suppliers. Entire lots of shipped parts are often rejected and send back to the supplier if just one defective part was found. The visual crack inspection by operators is in many production processes the last remaining production step that is massively performed manually.
Facing the problem of different interpretations of inspection instructions and the „human weaknesses“ like the inspection subjectivity, a possible lack of concentration, the personal situation, breaks, etc. one can derive an increasing demand to fulfill these tasks automatically with the help of industrial image processing.

The aim of the automatic crack inspection is a reproducible, objective inspection with very high throughput while simultaneously cutting the inspection costs.

This report demonstrates the transition from a visual (manual) to an automated (machine) inspection exemplarily.
Typically cracks on part surfaces shall be analyzed and classified accordingly.

This task can be split up into the part handling, the illumination, the image acquisition, the image processing, and the sorting respectively classification phase. A human fulfills these steps with a naturally ideal combination of the hand, eye, and the brain interactions. In addition a human is able to distinguish between defective and exemplary dirt.

How does a human inspect:

The parts are taken in the hand and rotated with adequate movements in all directions. With a constant illumination and the right presentation environment the cracks appear and can be identified.
The high performance and learning capabilities of the human brain enable a quick inspection of the defects. The modeling of these judgment and decision processes is the key challenge for the automization.
Despite these human abilities frequently defect misses of often major defects happen due to the above mentioned reasons. Broad follow-up studies show also that on one hand defective parts are mostly detected, however sorted wrongly. These sorting errors denote one of the major error sources.

How does a machine inspect:

An industrial inspection machine needs to model the above listed abilities ideally under the requirement to avoid misses reliably. In contrast to the human hand the machine cannot move the part to be inspected in any direction. It rather can repeat a clearly defined

presentation of the part. Therefore the defects need to be identified by an adequate illumination in combination with the arrangement of the part, the illumination, and the camera. In most cases this problem can be solved with very good results.

Handling

The machine cycle time of the parts to be inspected depends on the specifications of the magnetizing process. Typical, already implemented applications require 1.5 seconds per part. To meet this speed the parts have to be inspected during the movement. Depending on the part geometry flat parts are moved by a linear unit while rotational symmetric parts are additionally rotated around their rotation axis.

The machine cycle time of the parts to be inspected depends on the specifications of the magnetizing process. Continuous feeding rates of 1.2m/s are already possible.

Image acquisition:

Principally area scan and line scan cameras can be used to detect cracks. Area scan cameras for industrial use are today already available with resolutions of 1280 x 1024 pixels. Line scan cameras easily provide 4096 pixels or more.
For linear or rotational movements of the part a line scan camera is particularly suitable for the image acquisition. The speed of the parts is measured by a rotary transmitter so that speed variations cannot influence the inspection result. From the acquired lines an area image is constructed.
Reproducible inspection results require also that the camera is protected against dust and splash water and that the focus and aperture rings of the camera lens are fixed.
Typical optical resolutions lie in the range of 1/10mm. This resolution range is sufficient as the identifying setup enlarges the crack optically.

Illumination:

Long-life high-frequency linear lights or LED lights are mainly used. The life time of LED lights is about 100000 hours.

Software/Image processing:

The software is the heart of the automatic crack inspection. The better the decision processes of the human brain are modeled the more effective the inspection machine works. The graphical user interface of the inspection machine, running under MS-Windows, enables an easy interaction with the machine. Standard industry PCs are used.
The inspection software fulfills the following properties:

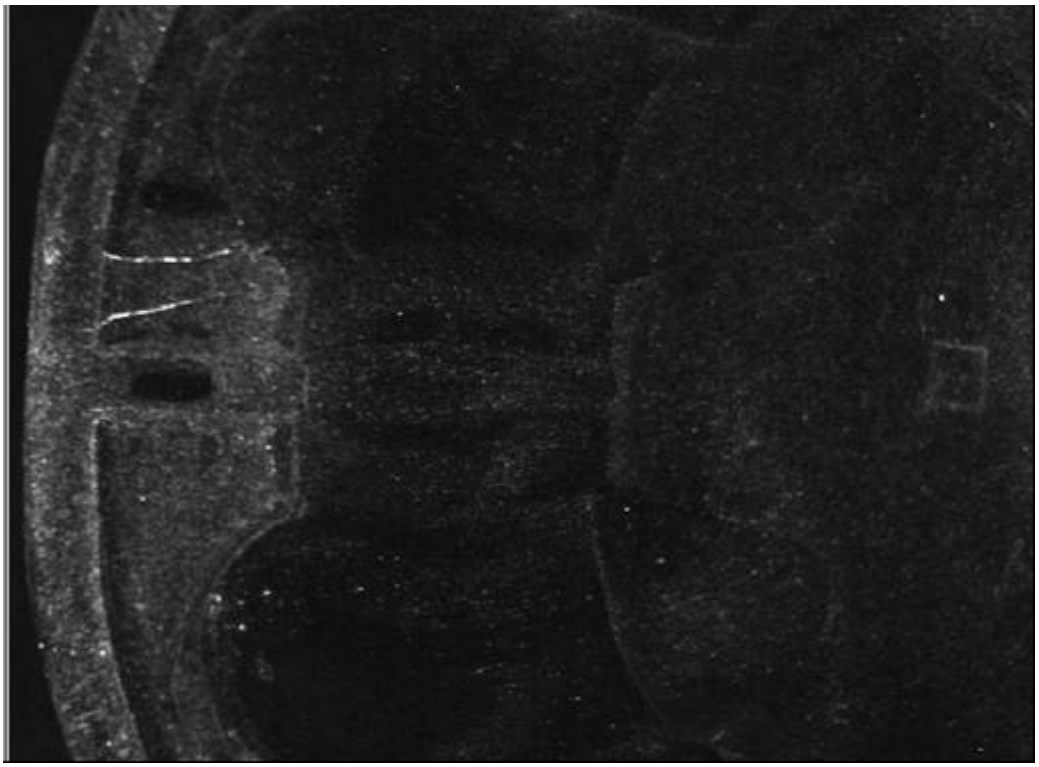
- Extremely short inspection time
- Tools to detect and analyze defects. Exemplary, slow gray scale changes can be distinguished from defects
- Tools to mask out parts on an object freely to avoid an inspection of this area. These masks can be either statically or dynamically placed in the camera image. Also the shape and size of the mask is adapted dynamically during the processing.
- Tools for an statistical analysis for quality data reports (SPC)
- Particular inspection software demands for crack inspection:
  - Elimination of the appearing background fluorescence
  - Fading out of concentrations of the inspection liquid
  - Checking if the inspection part was entirely showered with the flux liquid

- Automatic comparison with the master part
- Continuous inspection monitoring with the help of overlays in the camera image
- Specialized inspection methods for short cracks and heaps of short cracks
- Crack tracking: Connection of crack segments according to internally parameterizable rules

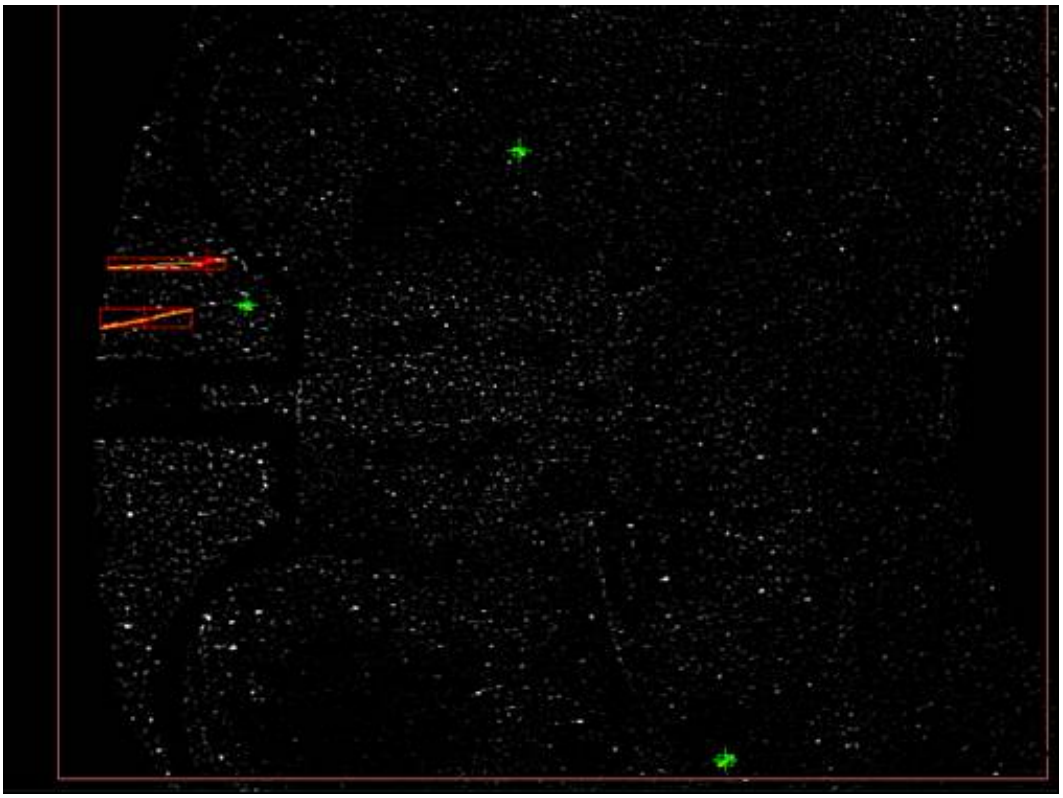
▪ Communication with the process via filed bus systems, network, RS 422/485, etc.

All parameters of the inspection machine are stored in initialization files and specified with the graphical user interface. They can be modified by the process engineer at any time. Thus it is possible to adapt the inspection machine fast and highly flexible to new inspection tasks. During the inspection the machine status, the statistical results, and the current inspection result is displayed. During the setup phase additionally the camera images as well as detail information is being displayed.
While the machine operator in general only enters the number of the part to be inspected, the process engineer defines the inspection criteria like the size of a defect or the occurrence per part. The machine is parameterized based on certain extreme cases.

Messzelle



Prüfling mit Rißanzeigen



Automatische Detektion der Risse

Computer:

Highly important is the use of standard components like systems based on industrial PCs. Computational power is necessary to be able to approach the human brain capabilities with the automated surface inspection software.

The company AUTOMATION W+R GmbH realizes automation projects since 1972. The company started 13 years ago to offer solutions for quality control tasks based on image processing. AUTOMATION W+R GmbH is proud to be one of the leading companies in the field of automated surface inspection and offers a broad spectrum of inspection machines including the parts handling for surface inspection applications of varieties of parts.

Executive summary:

- Industry proved solutions (steel mill, smithies, foundries, air and space industry)
- Short inspection times based on the inspection during the parts movement (up to 1.25 m/sec)
- Connection of segmented partial cracks
- Moistening verification
- Constant monitoring of all components
- Checking of the inspection liquid concentration
- Definition of the inspection field with the help of a graphical editor
- Unlimited inspection areas with different inspection criteria
- Long-life illumination