52. IWK

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COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

Session 6 - Environmental Systems: Management and Optimisation

Session 7 - New Methods and Technologies for Medicine and Biology

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision

Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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A. Jablonski / K. Kohrt / M. Böhm

Automatic quality grading of raw leather hides

ABSTRACT

The quality assessment of leather hides is to a large extent a tedious manual process. Although in the past many attempts have been started, up to now no working automatical system is available on the market. This is due to the large complexity of the task and the time constraints the system has to meet to become a reasonable alternative for human inspectors. We present a prototype system, which is currently in development but already achieves promising results in the rough production environment. We describe the challenges of the automatic grading of leather hides and explain the ideas behind the efficient and robust defect detection algorithms.

INTRODUCTION

Raw leather hides undergo a sophisticated sequence of processing steps: After removing remains of tissue, the hides are treated with salt and acid. Then they pass several tanning and dyeing steps. The complexity of this treatment varies depending on the quality of the raw leather: The better the quality, the fewer steps have to be passed, and the more cost-saving is the production. The quality also influences the market value of the leather, because the final usage ranges from high-value products like car seats, sofas or upper leather for shoes to small parts like leather belts.

Several attempts have been made to find a way to automize the quality control of tanned leather, but until now no practical solution has been found. The Leather Research Association (Forschungsgemeinschaft Leder e.V.) stated that there is no quality inspection system for industrial use available on the market.

The Fraunhofer Institute for Industrial Mathematics (Fraunhofer-Institut für Techno- und Wirtschaftsmathematik) in Kaiserslautern is working in a project together with a tannery in Sweden and the Swedish Fraunhofer-Chalmers Research Centre for Industrial Mathematics in Gothenburg. The objective is to find a way to grade hides automatically in the production process with the help of optical sensors and novel image processing methods. For this purpose, a prototype system has been integrated in the production line. The conditions at the tannery are very rough, humidity and dust are present everywhere, so all system components must be very robust or have to be enclosed in a protective case. Lighting and sensors have to be arranged carefully to deal with the low-contrast structures in the leather in the best possible way. Last but not least, additional challenges arise from the great demands on the defect detection algorithms that form the basis for the grading of the hides. The existing fast segmentation methods are simply unable to detect the relevant regions with reasonable false positives rates. The main difficulty is that many true defects are very similar to natural structures of the leather (Figure 1). Furthermore, the contrast of the defects can be weak and is not always proportional to their severity. The image processing algorithms have to deal with these complexities, and they have to do it fast, because approximately 100 megapixels of raw data have to be processed in 20 seconds.

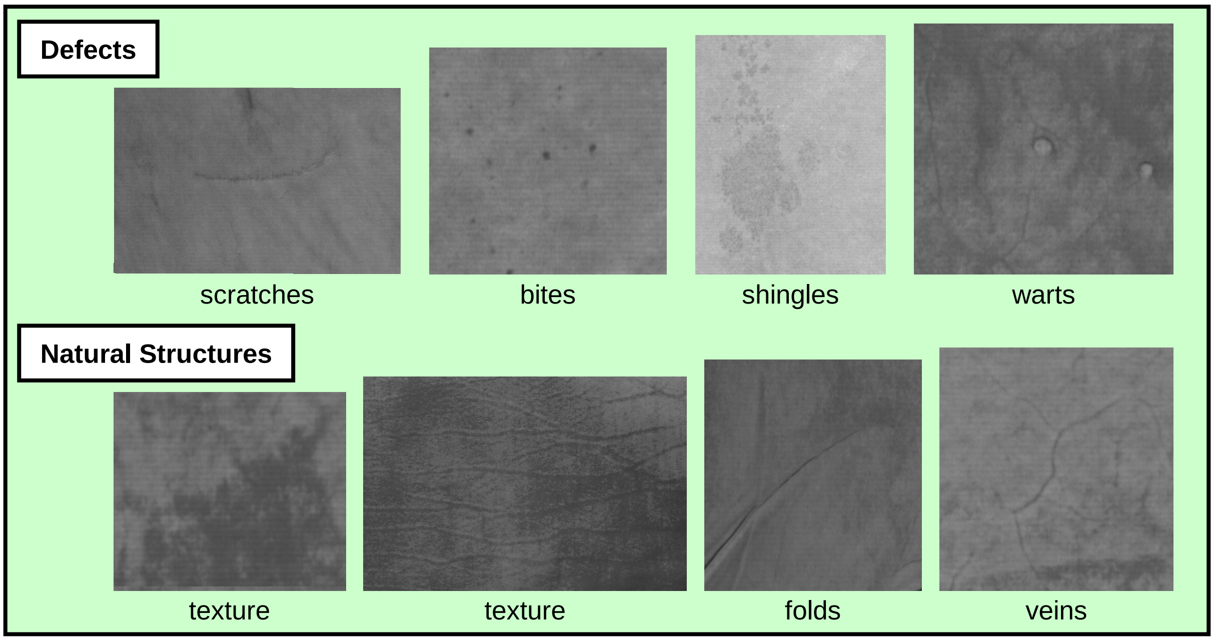

Figure 1: Unwanted (top row) and Natural (bottom row) Structures on Leather

FROM IMAGE TO GRADING

Starting from the acquired grayscale images, image analysis methods are applied to attain the grading result. The grading itself depends on the strength, the spatial distribution and the kind of defects present on the hide. A reliable and robust defect detection step is thus the basis for an accurate automatic grading.

The appearance of possible defects can be roughly characterized as follows: **Bites** are small and point-like dark spots, sometimes accumulated in clusters. **Scratches** appear as line segments and can be exceedingly thin. Their contrast ranges from very good to very poor and the intensity from dark to bright. Locally, they are similar to veins. **Warts** turn out to be bright shiny spots in the images. **Shingles** are agglomerations of circular spots with a complex geometry and usually of extremely poor contrast.

Different kinds of defects require different detection algorithms. The detection of warts and bites is the simplest and can be achieved with standard image processing methods. The detection of shingles is very difficult, the current prototype is not able to detect them reliably. In this article we concentrate on the scratch detection as scratches appear most frequently and the usual standard algorithms are not sufficient to detect them.

SCRATCH DETECTION ALGORITHM

The scratch detection algorithm consists of several processing steps (Figure 2): The preprocessing step (A) generates a binary image, the detection step (B) enhances and segments line like binary structures and the additional classification step (C) further suppresses the false positive detections.

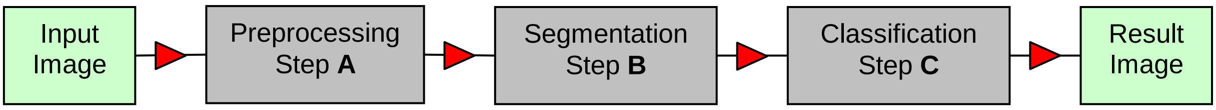

Figure 2: Image Processing Steps

To segment line like structures (i.e. potential scratches) in a highly noisy binary image two strategies are used. The first one relies on an adaptive anisotropic smoothing (**AAS**) and works well for images with sufficient contrast. The second one is more involved and consists of several iterations of adaptive erosion/dilation and reconstruction steps (**IEDR**). Both approaches try to obtain each candidate scratch as one connected region.

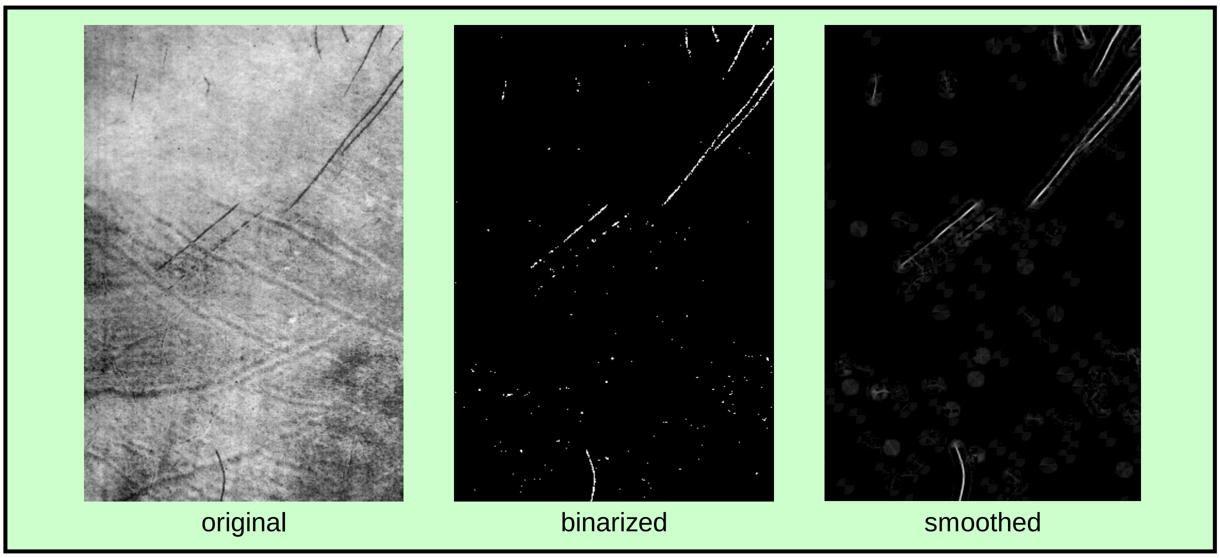

Figure 3: Scratch Detection using AAS

AAS (Figure 4) estimates the local covariance matrix from the data and smoothes the data in the direction of the largest variance. This effectively removes the binary noise and at the same time improves the contrast of candidate scratches (Figure 3).

Adaptive Anisotropic Smoothing

Input: binary image f
Output: gray level image g
Idea: find points concentrated on lines

$$g(p) = \sum_{(x,y)\in U(p)} w_p(x,y)\, f(x,y)$$

with weight:

$$w_p(x,y) = e^{-\frac{1}{2}(x\ y)\Sigma_p^{-1}\begin{pmatrix}x\\y\end{pmatrix}}$$

and covariance matrix:

$$\Sigma_p = \sum_{(x,y)\in U(p)} f(x,y)\begin{pmatrix}x\\y\end{pmatrix}(x\ y)$$

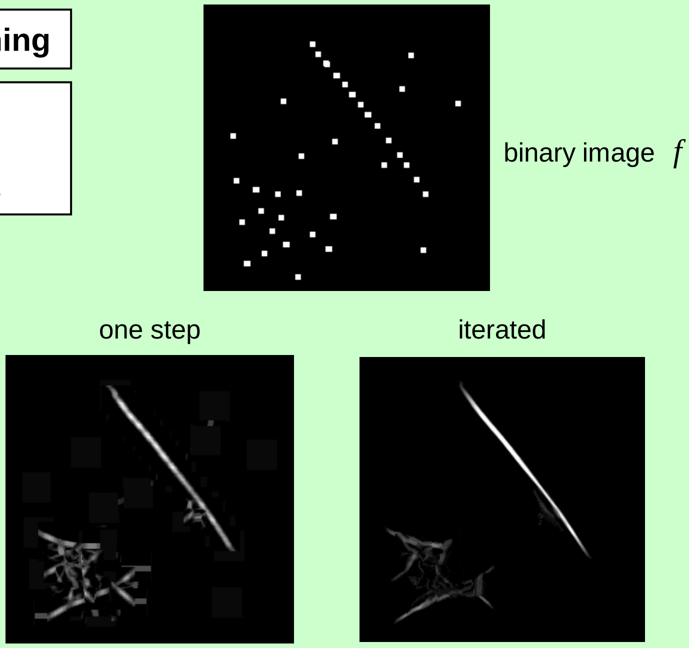

Figure 4: Adaptive Anisotropic Smoothing (AAS)

The **IEDR** approach (Figure 5, Figure 6) aims to connect the highly fragmented scratch candidates to obtain regions with large aspect ratio. The noise pixels are either removed or become connected components with low aspect ratio. After labeling with the aspect ratio and thresholding, only the correct regions remain (Figure 7).

Reconstruction by Dilation

Input: two gray level images f and h
Output: gray level image R_D
Idea: find connected maximal regions

$$R_D(f,h) = \lim_{r\to 0}\lim_{i\to\infty} g_i$$

$$g_0 = h,\quad g_{i+1} = Min(f, Max_r(g_i))$$

$$Max_r(g)(p) = \max_{(x,y)\in U_r(p)} g(x,y)$$

$$Min(g,h)(p) = \min(g(p), h(p))$$

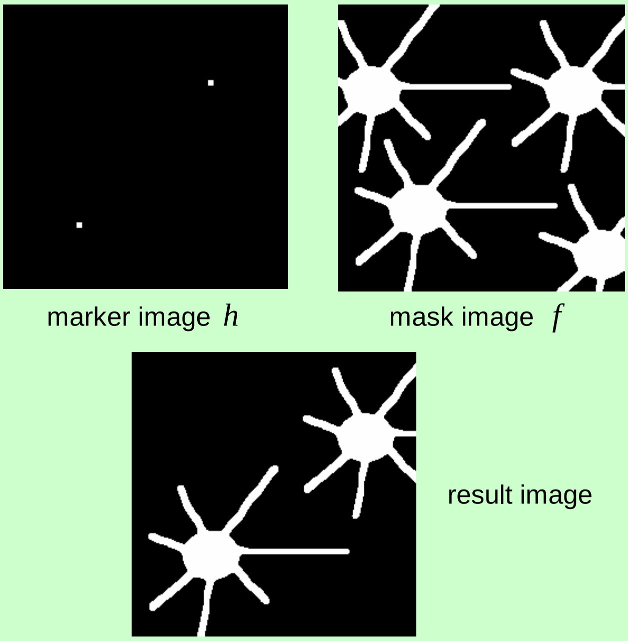

Figure 5: Reconstruction by Dilation

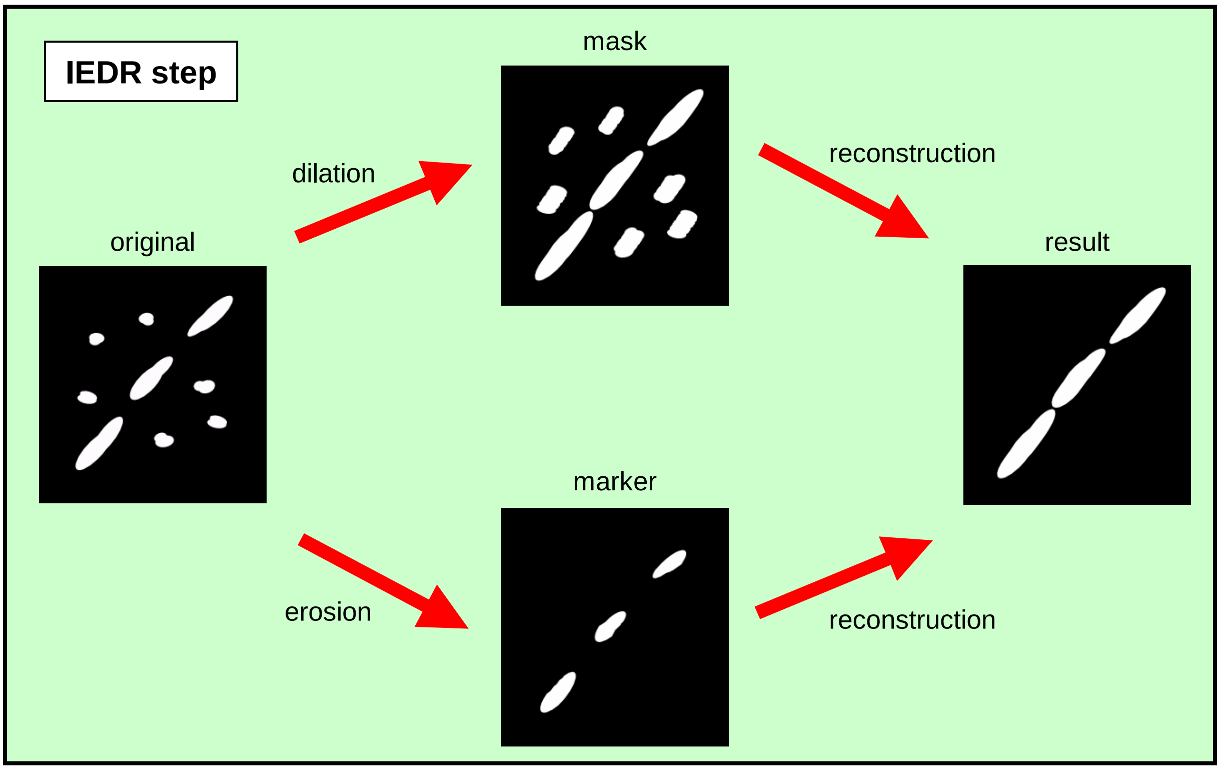

Figure 6: One IEDR Step

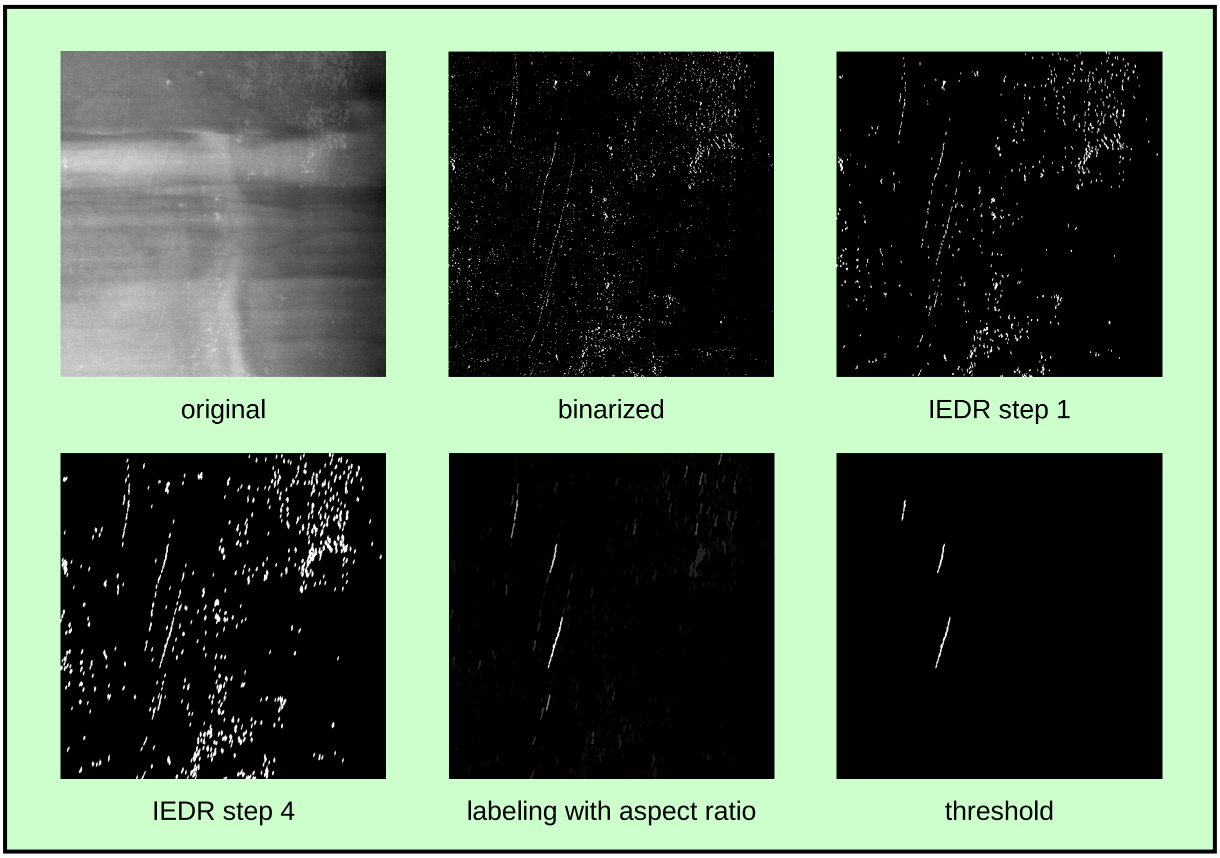

Figure 7: Scratch Detection using IEDR

SUMMARY

In the course of the mentioned cooperative project, a prototype system has been successfully integrated in the production process of a Swedish tannery. Image processing algorithms have been developed and implemented which already yield satisfying defect detection results. A reliable shingle detection algorithm is still in development, a method based on gray level geodesic reconstruction performs currently the best.

The prototype system achieves a processing speed of approximately 1 hide per minute instead of the aimed 3 hides per minute. Further improvements in the performance of the algorithms are thus still necessary.

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