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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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D. Hofmann / G. Linss

Application of Innovative Image Sensors for Quality Control

1. INTRODUCTION

Modern enabling technologies are working ever faster and in ever smaller scales. Main tasks of objective visual quality control with digital imaging are dimensional and color measurements [1]. In earlier days visual quality assurance with analog imaging have been expensive and the working area of specialists. Innovative vision sensors are more convenient, reliable and affordable (Table 1-1). Their bulk production and application is forthcoming.

Table 1-1 Vision Sensors from Cognex USA, Wenglor Germany and OMRON Japan

<table>
<tr>
<td>
</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVT 535 [2]</td>
<td>BS40V101 [3]</td>
<td>ZFV Color [4]</td>
</tr>
</table>

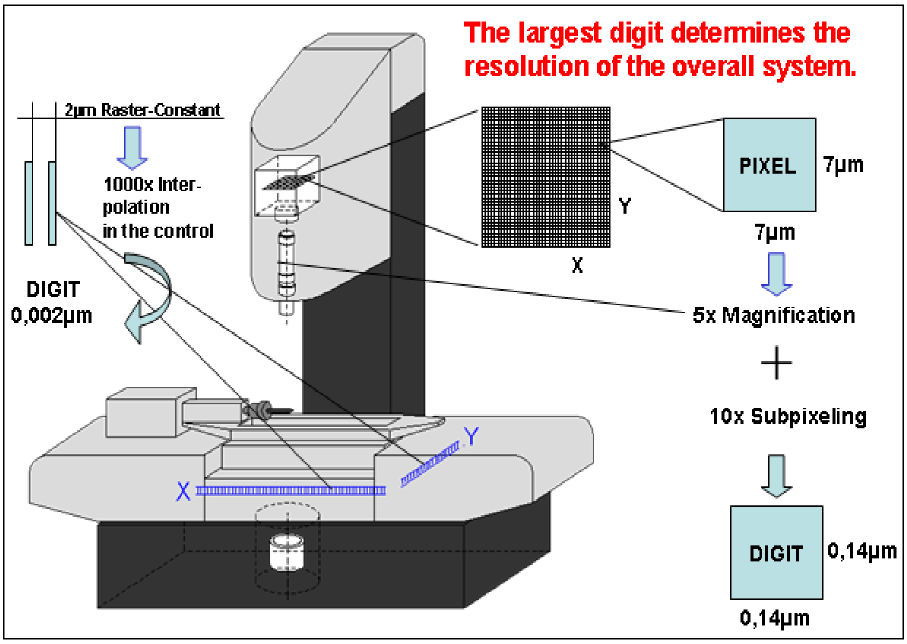
The future of visual quality assurance with imaging is digital, mobile, colored, miniaturized, standardized, networked and convergent. All these features support its fast growth in practical applications. But operation errors are risky. Aim of the paper is to show typical errors of visual quality measurements with digital imaging in micro scale and to give recommendations how to prevent them.

2. THE MEASUREMENT CHAIN WITH IMAGE SENSORS

Objective measurement is the comparison of a measurement object with a metrological standard. Reliable measurements are simple, if appropriate metrological standards, measurement methods, measurement instruments and mesurement software are available and a qualified measurement person is preparing, performing and evaluating the measurement.

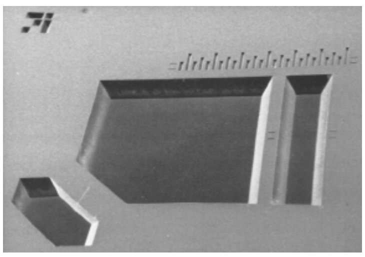
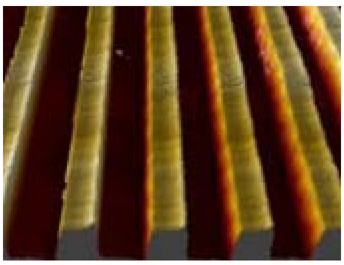
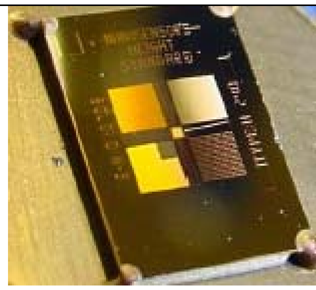
The accuracy, reproducibility and traceability of optical length measurements are dependent on a number of influencing parameters in the measurement chain (Table 2-1) [5]

Table 2-1 Measurement chain for quality assurance with digital imaging



3. INFLUENCES OF METROLOGICAL STANDARDS ON IMAGING

Metrological standards for the metre have a long history. They started in 1799 with metallic rules. Nowadays they are realized with modified laser interferometers [6]. The application of test standards for dimensionsional measurements in the micrometer and nanometre scale are still under investigation (Table 3-1 thru Table 3-3) [7].

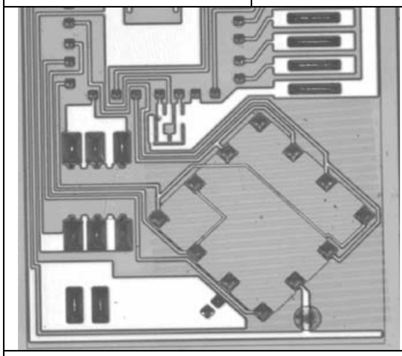
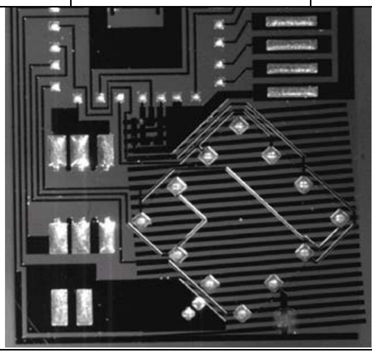
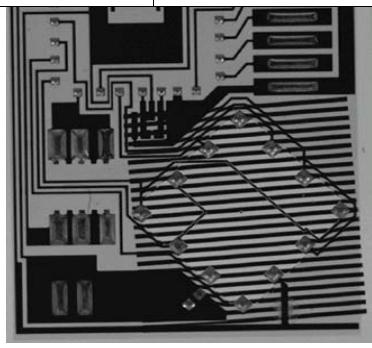
Table 3-1 Single Step Depth Setting Standard	Table 3-2 Periodic Step Setting Standards	Table 3-3 Step Grating Standards
		
50 nanometre … 1000 micrometre	20 nanometre … 1500 nanometre	8, 24, 80, 240, 800, 2 400 nanometre

4. INFLUENCES OF LIGHTING ON IMAGING

In optical measurements the image of the object and not the object itself is measured. It is said that lighting influences up to 60 % the success of optical measurements. Practical examples are given in Table 4-1 upper line [8] and lower line [9]

Table 4-1 Influences of lighting on the image of a measurement object

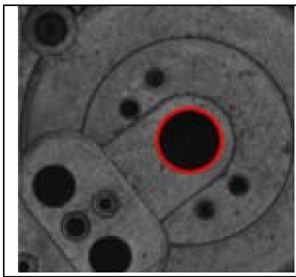
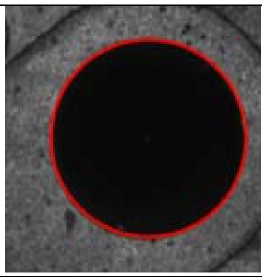
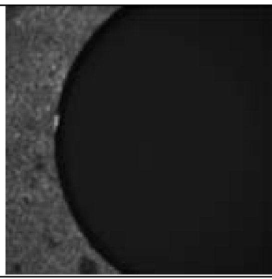
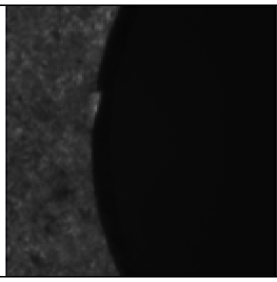
				
normal day light	coaxial light	low angle ring light	low angle LED array	one sided line light

		
incident light brightfield	incident light darkfield	transfer light brightfield

5. INFLUENCES OF MAGNIFICATION ON IMAGING

Strong influence on the accuracy of vision sensors has the magnification of the objective (Table 5-1) [10]

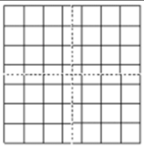
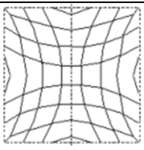
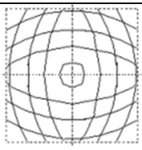
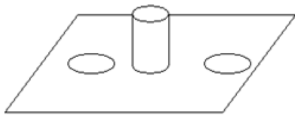
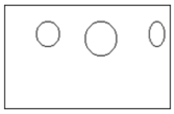
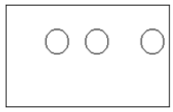
Table 5-1 GO and NO-GO magnifications for the optical measurement of a circle

			
objective 1,0x poor	objective 3,0x good	objective 5,0x poor	objective 10,0x very poor

6. INFLUENCES OF LENSES ON IMAGING

Influences on the accuracy of quality measurements with vision sensors have the optical quality of the lenses and the construction of the objectives (Table 6-1) [11]

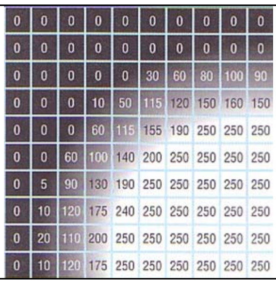
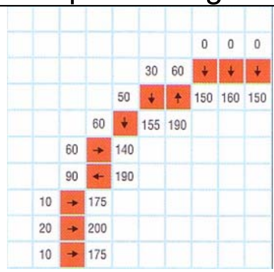
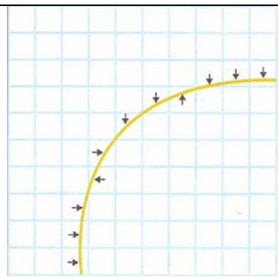
Table 6-1 Image errors caused by lens errors and construction of the objective

					
original image	cushion distorsion	barrel distorsion	measurement object	entocentric al objective	telecentrical objective

7. INFLUENCES OF SENSORS AND SOFWARE ON IMAGING

Optical digital precision measurements are knowing no sharp edges. The reasons are optical interferences at edges and pixeling of the sensors. Fundamental influences on the final results have the used algorithms for data processing with the embedded computers (Table 6-1) [12].

Table 7-1 Examples for interference and pixeling

measurement object	measurement values	measurement processing	measurement result
			
image of a hole	pixeling	subpixeling	edge

For real-time education and self-learning comprehensive e-papers and e-lectures are provided for example by [1] and [13].

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[1] www.visquanet.de
[2] www.cognex.com
[3] www.wenglor.de
[4] www.omron-industrial.com
[5] www.visquanet.de > Vorlesungen visuelle QS > V002 > page 22
[6] www.bipm.org/en/si/history-si/evolution_metre.html 070114
[7] www.nanoscale.de/standards.htm 070114.
[8] www.visquanet.de > Vorlesungen visuelle QS > V004 > page 24
[9] www.visquanet.de > Vorlesungen visuelle QS > V007 > page 23
[10] www.visquanet.de > Vorlesungen visuelle QS > V002 > page 18
[11] www.visquanet.de > Vorlesungen visuelle QS > V004 > pages 13, 20

[12] www.visquanet.de > Vorlesungen visuelle QS > V004 > pages 34, 35, 36
[13] www.keyence.de (German) and www.keyence.com (English)

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