Metrological Challenges for Quality Measurements with Vision Sensors

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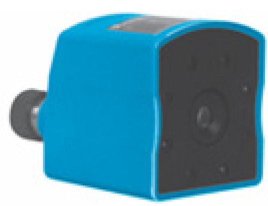
Abstract. *Vision sensors are innovative measurement systems for visual quality control with digital imaging. Vision sensors are convenient, reliable and affordable. Their bulk application is forthcoming. Unreliable measurements with vision sensors are possible due to unreflected error sources. Aim ot the paper is to call attention to particular features of optical measurements to reduce operating errors by undefined metrological standards for micro scales, unfavorable lighting conditions, suboptimal selection of magnification, lens manufacturing errors, construction of the objective, unknown sensor characteristics and unknown algorithms of the embedded computers. To reduce the risks of operating errors modern Internet portals provide visualized e-lectures for real-time eduction and self-learning.*
Keywords: vision sensors, measurement error, quality measurements, self-learning

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

		
DVT 535 [2]	BS40V101 [3]	ZFV Color [4]

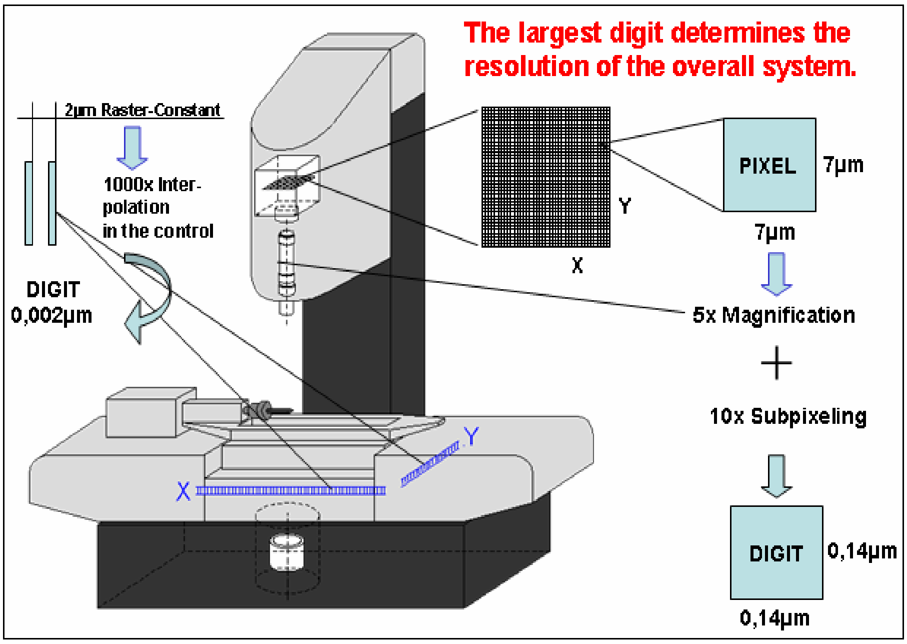
The future of visual quality assurance with imaging is digital, mobile, colored, miniaturized, standardized, networked and convergent. All these features support its fast growth in practical applications. But operation errors are risky. Aim of the paper is to show typical errors of visual quality measurements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

2. The Measurement Chain in Visual Quality Measurements with Vision 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.

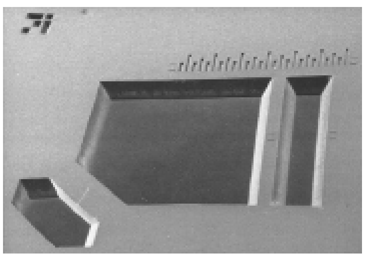
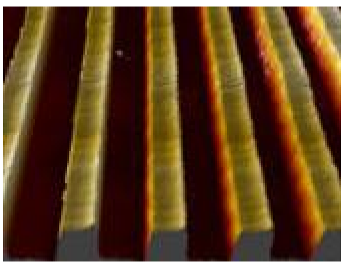
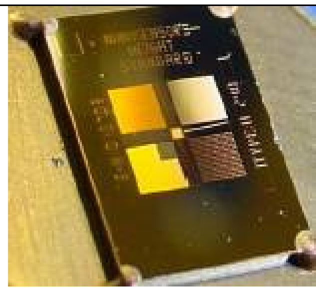
The accuracy, reproducibility and traceability of optical length measurements are dependent on a number of influencing parameters in the measurement chain (Table 2-1) [5]

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



3. Influences of Metrological Standards on Quality Measurements with Vision Sensors

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 appliction of test standards for dimensionsional measurements in the micrometer and nanometre scale are still under investigation (Table 3-1 thru Table 3-3) [7].

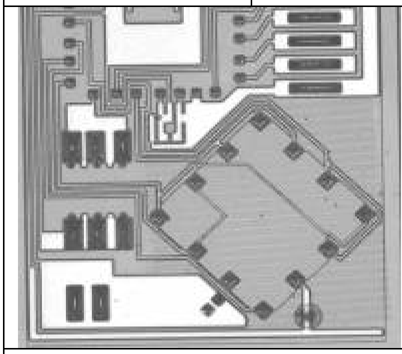
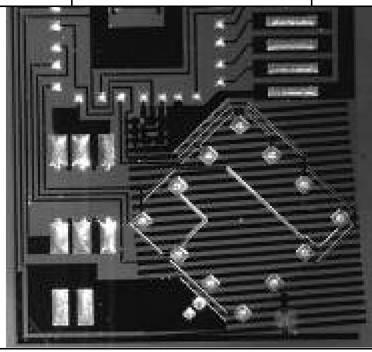
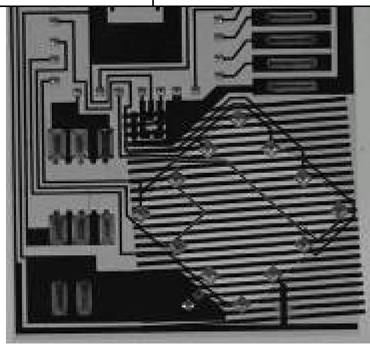
Table 3-1 Single Step Depth Setting Standard	Table 3-2 Periodic Step Setting Standards	Table 3-3 Step Grating Standards
		
50 nanometre … 1000 micrometre	20 nanometre … 1500 nanometre	8, 24, 80, 240, 800, 2 400 nanometre

4. Influences of Lighting on Quality Measurements with Vision Sensors

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

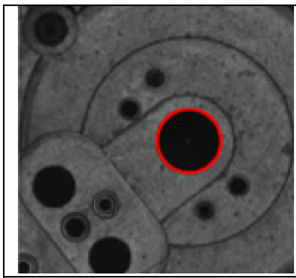
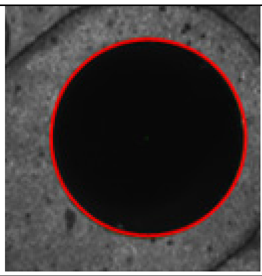
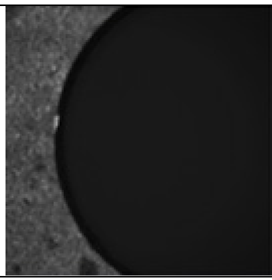
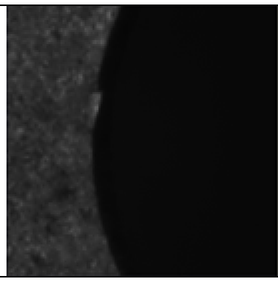
				
normal day light	coaxial light	low angle ring light	low angle LED array	one sided line light

		
incident light brightfield	incident light darkfield	transfer light brightfield

5. Influences of Magnification on Quality Measurements with Vision Sensors

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

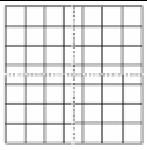
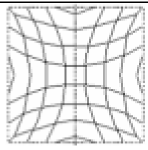
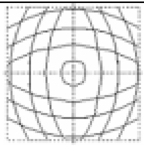
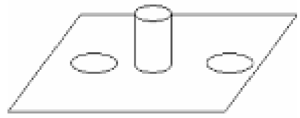
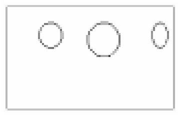
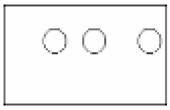
Table 5-1 GO and NO-GO magnifications for the optical measurement of a circle

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

6. Influences of Lenses on Quality Measurements with Vision Sensors

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]

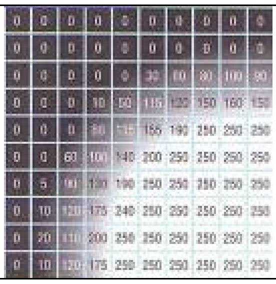
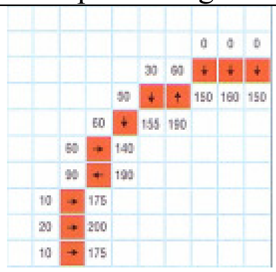
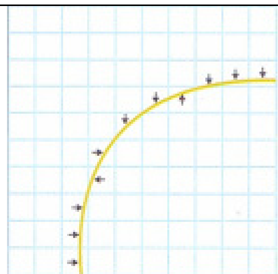
Table 6-1 Image errors caused by lens errors and construction of the objective

					
original image	cushion distorsion	barrel distorsion	measurement object	entocentrical objective	telecentrical objective

7. Influences of Sensors and Software on Quality Measurements with Vision Sensors

Optical digital precision measurements are knowing no sharp edges. The reasons are optical interferences at edges and pixels 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].

References

[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)