52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

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

TECHNISCHE UNIVERSITÄT
ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff

Redaktion: Referat Marketing und Studentische Angelegenheiten
Kongressorganisation
Andrea Schneider
Tel.: +49 3677 69-2520
Fax: +49 3677 69-1743
e-mail: kongressorganisation@tu-ilmenau.de

Redaktionsschluss: Juli 2007

Verlag:
Technische Universität Ilmenau/Universitätsbibliothek
Universitätsverlag Ilmenau
Postfach 10 05 65
98684 Ilmenau
www.tu-ilmenau.de/universitaetsverlag

Herstellung und Auslieferung: Verlagshaus Monsenstein und Vannerdat OHG
Am Hawerkamp 31
48155 Münster
www.mv-verlag.de

Layout Cover: www.cey-x.de

Bezugsmöglichkeiten: Universitätsbibliothek der TU Ilmenau
Tel.: +49 3677 69-4615
Fax: +49 3677 69-4602

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

Table of Contents

CONTENTS

Page

6 Environmental Systems: Management and Optimisation

T. Bernard, H. Linke, O. Krol 3
A Concept for the long term Optimization of regional Water Supply Systems as a Module of a Decision Support System

S. Röll, S. Hopfgarten, P. Li 11
A groundwater model for the area Darkhan in Kharaa river
Th. Bernard, H. Linke, O. Krol basin

A. Khatanbaatar Altantuul 17
The need designing integrated urban water management in cities of Mongolia

T. Rauschenbach, T. Pfützenreuter, Z. Tong 23
Model based water allocation decision support system for Beijing

T. Pfützenreuter, T. Rauschenbach 29
Surface Water Modelling with the Simulation Library ILM-River

D. Karimanzira, M. Jacobi 35
Modelling yearly residential water demand using neural networks

Th. Westerhoff, B. Scharaw 41
Model based management of the drinking water supply system of city Darkhan in Mongolia

N. Buyankhishig, N. Batsukh 47
Pumping well optimi ation in the Shivee-Ovoo coal mine Mongolia

S. Holzmüller-Laue, B. Göde, K. Rimane, N. Stoll 51
Data Management for Automated Life Science Applications

N. B. Chang, A. Gonzalez 57
A Decision Support System for Sensor Deployment in Water Distribution Systems for Improving the Infrastructure Safety

P. Hamolka, I. Vrublevsky, V. Parkoun, V. Sokol 63
New Film Temperature And Moisture Microsensors for Environmental Control Systems

N. Buyankhishig, M. Masumoto, M. Aley 67
Parameter estimation of an unconfined aquifer of the Tuul River basin Mongolia

M. Jacobi, D. Karimanzira 73
Demand Forecasting of Water Usage based on Kalman Filtering

7 New Methods and Technologies for Medicine and Biology

J. Meier, R. Bock, L. G. Nyúl, G. Michelson 81
Eye Fundus Image Processing System for Automated Glaucoma Classification

L. Hellrung, M. Trost 85
Automatic focus depending on an image processing algorithm for a non mydriatic fundus camera

M. Hamsch, C. H. Igney, M. Vauhkonen 91
A Magnetic Induction Tomography System for Stroke Classification and Diagnosis

T. Neumuth, A. Pretschner, O. Burgert 97
Surgical Workflow Monitoring with Generic Data Interfaces

M. Pfaff, D. Woetzel, D. Driesch, S. Toepfer, R. Huber, D. Pohlers, D. Koczan, H.-J. Thiesen, R. Guthke, R. W. Kinne 103
Gene Expression Based Classification of Rheumatoid Arthritis and Osteoarthritis Patients using Fuzzy Cluster and Rule Based Method

S. Toepfer, S. Zellmer, D. Driesch, D. Woetzel, R. Guthke, R. Gebhardt, M. Pfaff 107
A 2-Compartment Model of Glutamine and Ammonia Metabolism in Liver Tissue

J. C. Ferreira, A. A. Fernandes, A. D. Santos 113
Modelling and Rapid Prototyping an Innovative Ankle-Foot Orthosis to Correct Children Gait Pathology

H. T. Shandiz, E. Zahedi 119
Noninvasive Method in Diabetic Detection by Analyzing PPG Signals

S. V. Drobot, I. S. Asayenok, E. N. Zacepin, T. F. Sergiyenko, A. I. Svirnovskiy 123
Effects of Mm-Wave Electromagnetic Radiation on Sensitivity of Human Lymphocytes to Ionizing Radiation and Chemical Agents in Vitro

8 Embedded System Design and Application

B. Däne 131
Modeling and Realization of DMA Based Serial Communication for a Multi Processor System

M. Müller, A. Pacholik, W. Fengler 137
Tool Support for Formal System Verification

A. Pretschner, J. Alder, Ch. Meissner 143
A Contribution to the Design of Embedded Control Systems

R. Ubar, G. Jervan, J. Raik, M. Jenihhin, P. Ellervee 147
Dependability Evaluation in Fault Tolerant Systems with High-Level Decision Diagrams

A. Jutmann 153
On LFSR Polynomial Calculation for Test Time Reduction

M. Rosenberger, M. J. Schaub, S. C. N. Töpfer, G. Linß 159
Investigation of Efficient Strain Measurement at Smallest Areas Applying the Time to Digital (TDC) Principle

9 Image Processing, Image Analysis and Computer Vision

J. Meyer, R. Espiritu, J. Earthman 167
Virtual Bone Density Measurement for Dental Implants

F. Erfurth, W.-D. Schmidt, B. Nyuyki, A. Scheibe, P. Saluz, D. Faßler 173
Spectral Imaging Technology for Microarray Scanners

T. Langner, D. Kollhoff 179
Farbbasierte Druckbildinspektion an Rundkörpern

C. Lucht, F. Gaßmann, R. Jahn 185
Inline-Fehlerdetektion auf freigeformten, texturierten Oberflächen im Produktionsprozess

H.-W. Lahmann, M. Stöckmann 191
Optical Inspection of Cutting Tools by means of 2D- and 3D-Imaging Processing

A. Melitzki, G. Stanke, F. Weckend 197
Bestimmung von Raumpositionen durch Kombination von 2D-Bildverarbeitung und Mehrfachlinienlasertriangulation - am Beispiel von PKW-Stabilisatoren

F. Boochs, Ch. Raab, R. Schütze, J. Traiser, H. Wirth 203
3D contour detection by means of a multi camera system

M. Brandner 209
Vision-Based Surface Inspection of Aeronautic Parts using Active Stereo

H. Lettenbauer, D. Weiss 215
X-ray image acquisition, processing and evaluation for CT-based dimensional metrology

K. Sickel, V. Daum, J. Hornegger 221
Shortest Path Search with Constraints on Surface Models of In-the-ear Hearing Aids

S. Husung, G. Höhne, C. Weber 227
Efficient Use of Stereoscopic Projection for the Interactive Visualisation of Technical Products and Processes

N. Schuster 233
Measurement with subpixel-accuracy: Requirements and reality

P. Brückner, S. C. N. Töpfer, M. Correns, J. Schnee 239
Position- and colour-accurate probing of edges in colour images with subpixel resolution

E. Sparrer, T. Machleidt, R. Nestler, K.-H. Franke, M. Niebelschütz 245
Deconvolution of atomic force microscopy data in a special measurement mode – methods and practice

T. Machleidt, D. Kapusi, T. Langner, K.-H. Franke 251
Application of nonlinear equalization for characterizing AFM tip shape

D. Kapusi, T. Machleidt, R. Jahn, K.-H. Franke 257
Measuring large areas by white light interferometry at the nanopositioning and nanomeasuring machine (NPMM)

R. Burdick, T. Lorenz, K. Bobey 263
Characteristics of High Power LEDs and one example application in with-light-interferometry

T. Koch, K.-H. Franke 269
Aspekte der strukturbasierten Fusion multimodaler Satellitendaten und der Segmentierung fusionierter Bilder

T. Riedel, C. Thiel, C. Schmullius 275
A reliable and transferable classification approach towards operational land cover mapping combining optical and SAR data

B. Waske, V. Heinzel, M. Braun, G. Menz 281
Classification of SAR and Multispectral Imagery using Support Vector Machines

V. Heinzel, J. Franke, G. Menz 287
Assessment of differences in multisensoral remote sensing imageries caused by discrepancies in the relative spectral response functions

I. Aksit, K. Bünger, A. Fassbender, D. Frekers, Chr. Götze, J. Kemenas 293
An ultra-fast on-line microscopic optical quality assurance concept for small structures in an environment of man production

D. Hofmann, G. Linss 297
Application of Innovative Image Sensors for Quality Control

A. Jablonski, K. Kohrt, M. Böhm 303
Automatic quality grading of raw leather hides

M. Rosenberger, M. Schellhorn, P. Brückner, G. Linß 309
Uncompressed digital image data transfer for measurement techniques using a two wire signal line

R. Blaschek, B. Meffert 315
Feature point matching for stereo image processing using nonlinear filters

A. Mitsiukhin, V. Pachynin, E. Petrovskaya 321
Hartley Discrete Transform Image Coding

S. Hellbach, B. Lau, J. P. Eggert, E. Körner, H.-M. Groß 327
Multi-Cue Motion Segmentation

R. R. Alavi, K. Brieß 333
Image Processing Algorithms for Using a Moon Camera as Secondary Sensor for a Satellite Attitude Control System

S. Bauer, T. Döring, F. Meysel, R. Reulke 341
Traffic Surveillance using Video Image Detection Systems

M. A-Megeed Salem, B. Meffert 347
Wavelet-based Image Segmentation for Traffic Monitoring Systems

E. Einhorn, C. Schröter, H.-J. Böhme, H.-M. Groß 353
A Hybrid Kalman Filter Based Algorithm for Real-time Visual Obstacle Detection

U. Knauer, R. Stein, B. Meffert 359
Detection of opened honeybee brood cells at an early stage

10 Mobile Communications

K. Ghanem, N. Zamin-Khan, M. A. A. Kalil, A. Mitschele-Thiel 367
Dynamic Reconfiguration for Distributing the Traffic Load in the Mobile Networks

N. Z.-Khan, M. A. A. Kalil, K. Ghanem, A. Mitschele-Thiel 373
Generic Autonomic Architecture for Self-Management in Future Heterogeneous Networks

N. Z.-Khan, K. Ghanem, St. Leistritz, F. Liers, M. A. A. Kalil, H. Kärst, R. Böringer 379
Network Management of Future Access Networks

St. Schmidt, H. Kärst, A. Mitschele-Thiel 385
Towards cost-effective Area-wide Wi-Fi Provisioning

A. Yousef, M. A. A. Kalil 391
A New Algorithm for an Efficient Stateful Address Autoconfiguration Protocol in Ad hoc Networks

M. A. A. Kalil, N. Zamin-Khan, H. Al-Mahdi, A. Mitschele-Thiel 397
Evaluation and Improvement of Queueing Management Schemes in Multihop Ad hoc Networks

M. Ritzmann 403
Scientific visualisation on mobile devices with limited resources

R. Brecht, A. Kraus, H. Krömker 409
Entwicklung von Produktionsrichtlinien von Sport-Live-Berichterstattung für Mobile TV Übertragungen

N. A. Tam 421
RCS-M: A Rate Control Scheme to Transport Multimedia Traffic over Satellite Links

Ch. Kellner, A. Mitschele-Thiel, A. Diab 427
Performance Evaluation of MIFA, HMIP and HAWAII

A. Diab, A. Mitschele-Thiel 433
MIFAv6: A Fast and Smooth Mobility Protocol for IPv6

A. Diab, A. Mitschele-Thiel 439
CAMP: A New Tool to Analyse Mobility Management Protocols

11 Education in Computer Science and Automation

S. Bräunig, H.-U. Seidel 447
Learning Signal and Pattern Recognition with Virtual Instruments

St. Lambeck 453
Use of Rapid-Control-Prototyping Methods for the control of a nonlinear MIMO-System

R. Pittschellis 459
Automatisierungstechnische Ausbildung an Gymnasien

A. Diab, H.-D. Wuttke, K. Henke, A. Mitschele-Thiel, M. Ruhwedel 465
MAeLE: A Metadata-Driven Adaptive e-Learning Environment

V. Zöppig, O. Radler, M. Beier, T. Ströhla 471
Modular smart systems for motion control teaching

N. Pranke, K. Froitzheim 477
The Media Internet Streaming Toolbox

A. Fleischer, R. Andreev, Y. Pavlov, V. Terzieva 485
An Approach to Personalized Learning: A Technique of Estimation of Learners Preferences

N. Tsyrelchuk, E. Ruchaevskaia 491
Innovational pedagogical technologies and the Information educational medium in the training of the specialists

Ch. Noack, S. Schwintek, Ch. Ament 497
Design of a modular mechanical demonstration system for control engineering lectures

52^{nd} Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

D. Kapusi / T. Machleidt / K.-H. Franke / E. Manske / R. Jahn

Measuring large areas by white light interferometry at the nanopositioning and nanomeasuring machine (NPMM)

Abstract

White light interferometry is a new application for the nanopositioning and nanomeasuring machine (NPMM). The NPMM was developed under the leadership of the Institute of Process Measurement and Sensor Technology at the Technische Universität Ilmenau (Germany) and allows highly exact dimensional and traceable positioning with a resolution of 0.1 nm within a volume of 25 mm x 25 mm x 5 mm.

White light interferometry can profit from these features and can take over the device's very high precision and large effective range.

Individual effective areas can be exactly positioned on the lateral level so that they become adjacent to each other and can be stitched together to a common height data map without the use of CPU-intensive registration algorithms, which effectiveness in general are depended on the topology of the measuring object. The article deals with therefore necessary calibration methods to determine and to consider the alignment of the white light sensor according to the machine coordinate system.

Motivation

At the Technische Universität Ilmenau (TU Ilmenau) a nanopositioning and nanomeasuring machine (NPMM) has been continuously developed within the scope of the collaborative research centre SFB 622. The fundamental and innovative concept of the NPMM is the realization of the Abbe comparator principle in all three measuring axes [1] − that means that the measuring probe and the measuring beams of the machine must be aligned. This has the effect that systematic and random tilting of the guiding elements, also called as first-order tilt errors, are avoided.

The consequent observance of the principle has made possible a state-of-the-art nanopositioning and nanomeasuring machine with a measuring volume of 25 mm x 25 mm x 5 mm and a resolution of 0.1 nm [1, 2]. Besides the large effective range and the high resolution a significant advantage of the device is, that several different measuring methods can be applied. The different types of sensors are quickly and easily changeable because of their modular conception.

So far atomic force microscopes, focus sensors as well as capacitive and inductive contact systems are applicable sensor types for the NPMM [3]. However, data capture for these sensors is limited to one dimension. This also means that the measurement time requirements on these sensors cannot ever be met.

The integration of white light interferometry into the NPMM [4] is one of the current research and development topics of the Computer Graphics Group (TU Ilmenau).

White light interferometry is a powerful optical measuring method that allows the capturing of a whole surface with very high precision within a measurement time of a few seconds, depending on the topology of the measuring probe.

White light interferometry can profit from the high positioning resolution and large measuring volume of the NPMM. Hence, the main disturbing influence to the measurement's accuracy, the positioning noise, almost can be avoided.

In contrast to modern conventional white light interferometers, which perpendicular pass trough ranges are limited in general to 100 µm, the combination with the NPMM allows the measurement of height differences up to 5 mm. The measuring time can be accelerated significantly by skipping the height regions where no fringes occur with a coarse speed (up to 50 mm/s [2]) during the perpendicular scan (e. g. the range between the top and the bottom of a step height). Fig. 1 shows an average profile of an in this manner measured structure with step height over 1 mm. This measuring has taken only a few seconds.

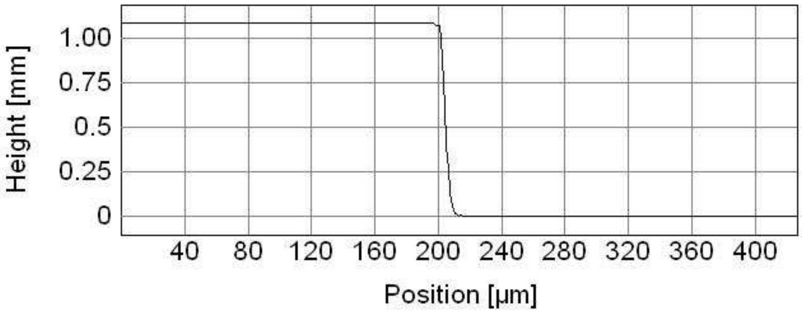

Fig. 1 Profile of a 1.089 mm step height standard, measured with each a pass trough range on the bottom and on the top of the sample

The nanometre-precision lateral positioning of the NPMM permits accurate stitching for the analysis of large areas. The most white light interferometry applications, who provide the stitching technique, are using matching algorithms to register height data maps, which have to be overlapped to each other. In the overlaid sections, the observed structure must show significant features, like edges, otherwise the registration don't works correctly. All uncertainties from single registration steps have an adding up influence to the total lateral positioning inaccuracy. These disadvantages can be avoided by an exact positioning of adjacent individual effective areas without matching algorithms.

Adjustment and consideration of the perpendicular sensor alignment

An important condition for measuring large ranges in vertical direction by white light interferometry is, that the sensor has to be aligned orthogonal in relation to the machine coordinate system. If the sensor, which contains a CCD camera, is tilted, than the lateral observed position shifts away proportional to the vertical moving distance.

The whole measuring head can be aligned manually by adjusting screws in consideration of fringes (a flat mirror is suggested as a measuring object for this adjustment).

It is improbable that a perfect alignment can be reached by a manually adjustment, the tilt can only be minimized.

If the remaining tilt of the sensor in accordance to the machine coordinates is not considered, than the resulting height data from each individual measurement are displaced in the height direction to each other by a constant offset depended from the lateral position of the individual effective area. These offsets have to be corrected, if the results from adjacent measurements should be stitched.

Calibration of the lateral sensor alignment

In order to allow an exact probe placement in respect to the lateral position of the sensor's effective area the transformation parameters from the sensor to the machine coordinates have to be determined.

Therefore a calibration procedure is performed in the run-up to the measurements for the estimation of the alignment and the scale factor. Under the assumption, that the sensor is justified perpendicular to the machine coordinate system (due to the manual adjustment), the alignment can be simplified characterized by a rotation about the angle phi_{rot} (Fig. 2) on the lateral level.

The idea of the calibration method is to register a list of pass points between two images of the same target object, which have been captured at different lateral positions. An average translation vector is calculated over all corresponding point pairs. Between the known translation vector of the machine coordinates and the translation vector between the pass points from the images the rotation angle and the scale factor can be determined.

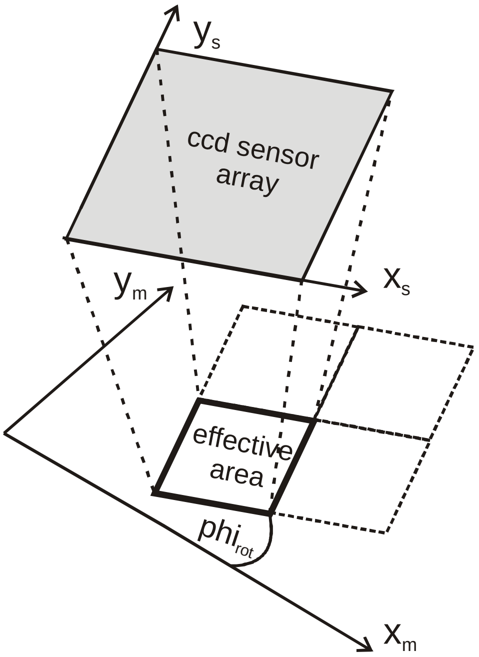

Fig. 2 Relation between the sensor- (xs, ys) and the machine coordinates (xm, ym)

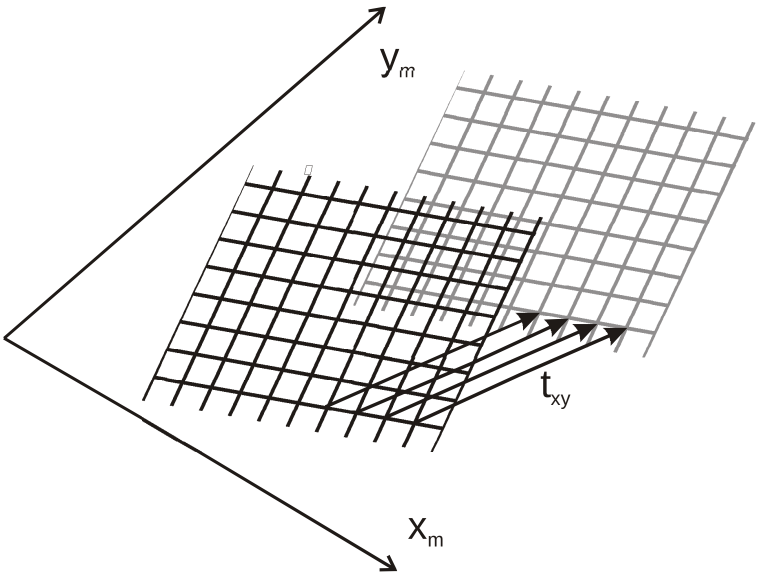

Fig. 3 Lateral translation of the calibration grid by vector t_{xy}

As a calibration target a grid structure is used, which crossing points are threaded as the points of interest. The gridlines are robust detectable by means of the Hough-transformation. The Hough-transformation is significantly speeded up, because the plausible search interval in the line parameter domain can be limited under the consideration of the previously rough estimated gradient direction at each pixel position. The assignment of the pass points between the two images is followed by the Nearest-Neighbor-principle, which assumes that the transformation parameters are a priori roughly known. The necessary precision of the a priori transformation parameters is depended on the line spacing of the grid and the translation distance between the two images.

Exemplary results

A layer thickness standard was measured. The results of four individual measurements of adjacent effective areas were stitched to a common height data map with a lateral effective area of 1.64 x 1.23 mm^2 and a lateral resolution of 1.25 Pixel/µm, which is shown below in Fig. 4. The remaining tilt of the sensor was corrected for each measurement by adding a constant height offset.

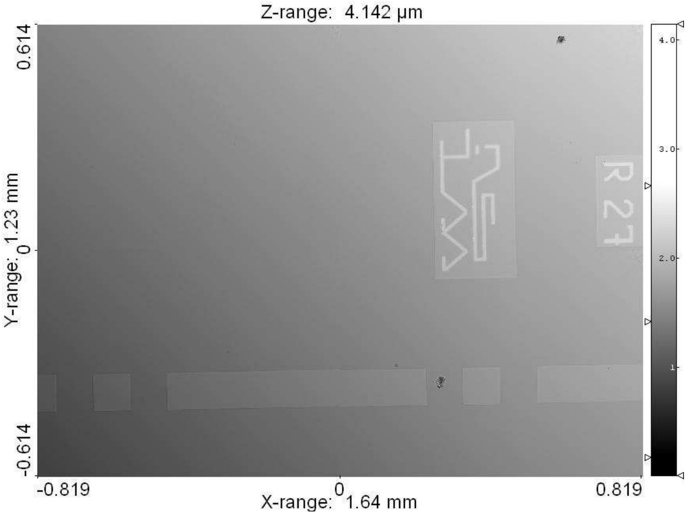

Fig. 4 Stitched height image from a layer thickness standard

Conclusion

A calibration procedure for determining the lateral alignment and scale of the white light interferometry measuring sensor have been put into practice by means of a robust and sub pixel precise pass point assignment between the images of a grid at different lateral positions. Therewith the conditions for an exact lateral positioning in accordance to the sensor coordinates are complied.

Therefore, in contrast to conventional stitching methods, the results from individual measurements at adjacent lateral positions can be linked without matching algorithms, which precision is depending in general from the topology of the measuring object. The developments were able to be exemplary proven by stitching of the adjacent measurement results from a layer thickness standard to a common height data map (Fig. 4).

Acknowlishments

The project white light interferometry for nanopositioning and nanomeasuring machines has been sponsored by the ministry of education and arts of the Free State of Thuringia (Germany) under the sign B 514-06 007. The authors wish to thank all those colleagues at the Technische Universität Ilmenau and the ZBS Ilmenau e. V., who have contributed to these developments.

References:

[1] Nanopositioning and Measuring Machine, Proceedings of the 2nd euspen International Conference (pages 290-293), European Society for Precision Engineering and Nanotechnology, 2001.
[2] Nanopositionier- und Nanomessmaschine, data sheet 10/ 2005, SIOS Messtechnik GmbH, Ilmenau, 2005.
[3] G. Jäger, E. Manske and T. Hausotte, Neue Anwendungen der Nanomessmaschine (NPM-Maschine) durch die Entwicklung nanoskaliger optischer und taktiler Tastsensoren, Technisches Messen 73 (2006) 9, Oldenburg Verlag, 2006.
[4] D. Kapusi, T. Machleidt, K.-H. Franke, R. Jahn, White light interferometry in combination with a nanopositioning and nanomeasuring machine (NPMM), Proceedings SPIE Optical Metrology, Paper Number: 6616-4, Munich, 2007.

Authors:

Dipl.-Ing. Daniel Kapusi
TU-Ilmenau, EAZ Ehrenbergstr. 29, Room 0322
98693, Ilmenau
Phone: (0)493677 695073
Fax: (0)493677 695071
E-mail: daniel.kapusi@tu-ilmenau.de

Dipl.-Ing. Torsten Machleidt
TU-Ilmenau, EAZ Ehrenbergstr. 29, Room 0321
98693, Ilmenau
Phone: (0)493677 695068
Fax: (0)493677 695071
E-mail: torsten.machleidt@tu-ilmenau.de

PD Dr.-Ing. habil. Karl-Heinz Franke
TU-Ilmenau, APZ Gustav-Kirchhoff-Str. 5
98693, Ilmenau
Phone: (0)493677 2010300
Fax: (0)493677 2010302
E-mail: karl-heinz.franke@tu-ilmenau.de

Dr.-Ing. habil. Eberhard Manske
TU-Ilmenau, Gustav-Kirchhoff-Str. 1, Room K2004
98693, Ilmenau
Phone: (0)493677 691250
Fax: (0)493677 691412
E-mail: eberhard.manske@tu-ilmenau.de

Dr.-Ing. Rainer Jahn
ZBS Ilmenau e. V., APZ Gustav-Kirchhoff-Str. 5
98693, Ilmenau
Phone: (0)493677 2010310
Fax: (0)493677 2010302
E-mail: rainer.jahn@zbs-ilmenau.de