FernUniversität in Hagen

Fachbereich Elektrotechnik und Informationstechnik

Elektrotechnik und Informationstechnik
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Jahresbericht Annual Report

Table of Contents

Introduction

This will be the last report of the "*Fachbereich Elektrotechnik und Informationstechnik*". On April 1st, 2006, the department will merge in a Faculty of Mathematics, Computer Science and Information Technology (*Fakultät für Mathematik, Informatik und Informationstechnik*).

Not surprisingly, the merging process is painful, the role of engineering at the FernUniversität is significantly diminished which is symbolized, for example, by the disappearance of the term *Elektrotechnik* in the name. But does it, at least, make sense from an objective point of view?

German industry suffers from an acute shortage of engineers. VDI and BMBF estimate that just in the small and medium enterprises there are now 11,500 engineers missing with increasing tendency. In a country where science and engineering are the sole resource for tomorrow's products, strong support for these disciplines would appear normal and necessary. Will other disciplines be able to create the foundation for new technologies and new jobs?

Does it make sense to cut science and engineering at a small university? From a cost-savings point of view, may be. One might view this as a matter of local optimization in a general situation where universities redefine themselves. From a more general point of view support for science and engineering is an investment in the future.

Hagen, February 2006 Jürgen Jahns

formerly chair of

Allgemeine und Theoretische Elektrotechnik

(Fundamentals and Theory of Electromagnetics)

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Staff:	Phone
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Wolfgang Benner	1149
Dr.-Ing. Hans–Georg Bergandt	1142
Dr.-Ing. Stefan Helfert	1144
Prof. Dr.-Ing. Wilfrid Pascher	1145
Georg Schindel	1152
Dipl.-Ing. Werner Schubert	1149
Doris Weyerbusch	1141

Oblique Coordinates in the Method of Lines

Stefan F. Helfert

Motivated by papers found in the literature [1], [2], [3] oblique coordinates were introduced into the method of lines [4]. For the purpose of analysis suitable equations had to be derived. To test the correct implementation of the algorithm the connection of two vertical waveguides by a tilted one was examined (see Fig. 1).

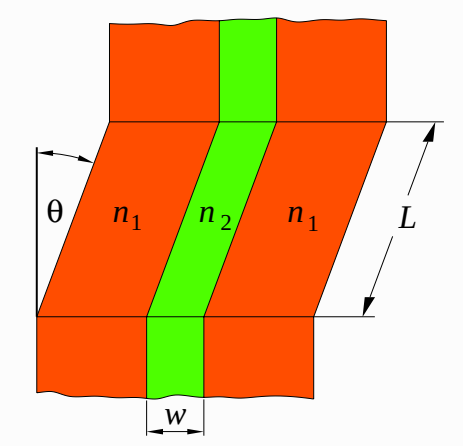

Fig. 1: Connection of two vertical waveguides by a tilted one

The output power as function of the angle θ is shown in Fig. 2. For comparison we used also the method of lines with a staircase approximation. All curves agree very well. It should be mentioned that there are two reason for the decrease of the power: a) the loss due to the bend, b) the width of the tilted waveguide part is smaller than that of the vertical ones.

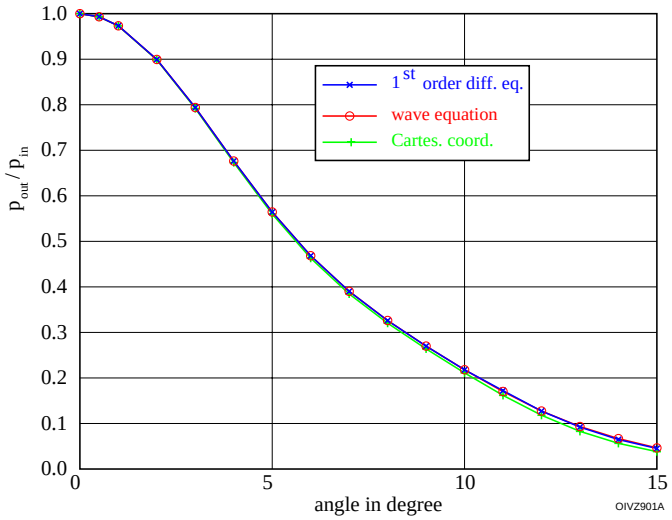

Fig. 2: Output power in a tilted waveguide structure

[1] J. Yamauchi, J. Shibayama, and H. Nakano, "Propagating Beam Analysis Based on the Implicit Finite–Difference Method using the Oblique Coordinate System", in *OSA Integr. Photo. Resear. Tech. Dig.*, San Francisco, USA, Feb. 1994, pp. 19–21.

[2] T. M. Benson, P. Sewell, S. Sujecki, and P. C. Kendall, "Structure related beam propagation", *Opt. Quantum Electron.*, vol. 31, pp. 689–703, 1999, Special Issue on Optical Waveguide Theory and Numerical Modelling.

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Oblique Coordinates for Computing Band Structures

Stefan F. Helfert

The elementary cells in in hexagonal photonic crystals are not rectangular, but are made of parallelograms like the one shown in Fig. 1 with the corner points A-B-4-5. To compute the bands in such structures oblique coordinates were introduced in the method of lines.

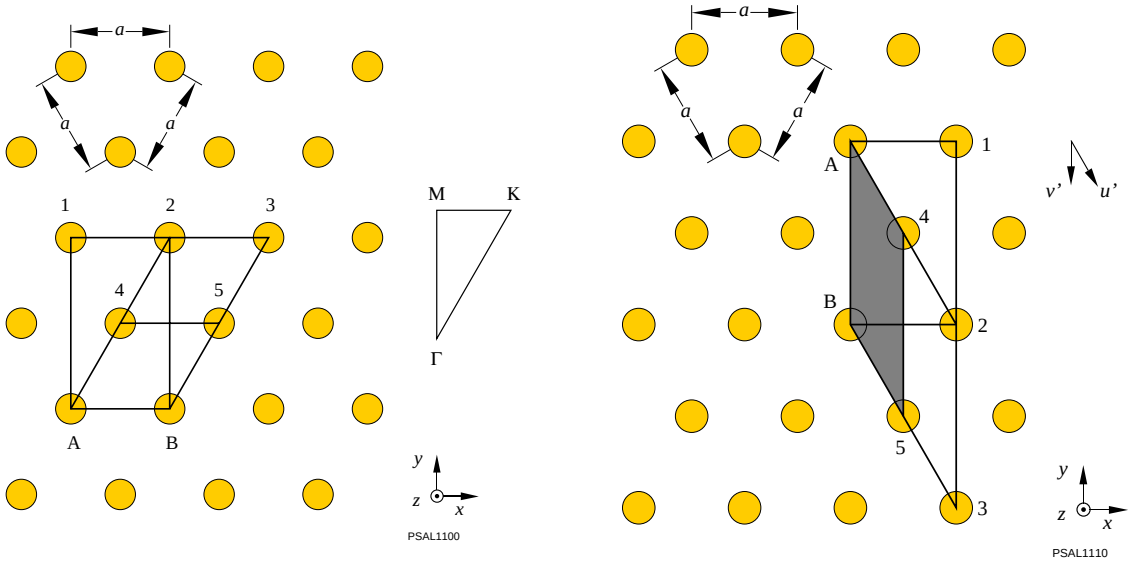

Fig. 1: Elementary cell for computing a) the Γ–M band, b) the Γ–K and the M–K band

Depending on the direction of propagation, different elementary cells have to be considered as shown in Fig. 1a,b. Results are shown in Fig. 2. A comparison of values in the points Γ,M and K shows a good agreement with those presented in [1].

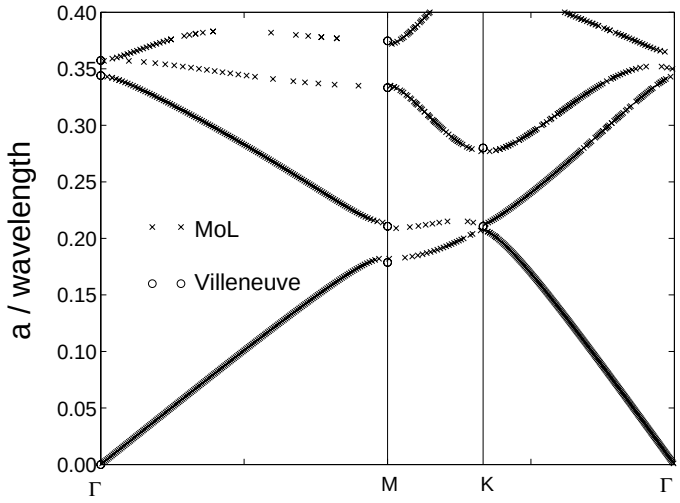

Fig. 2: Band diagram for a hexagonal lattice, structure parameters taken from [1].

[1] P. R. Villeneuve, S. Fan, S. G. Johnson, , and J. D. Joannopoulos, "Three–dimensional photon confinement in photonic crystals of low–dimensional periodicity", *IEE Proc.-Optoelectron.*, vol. 145, no. 6, pp. 384–390, 1998.

Boundary conditions for analyzing periodic structures with the method of lines

Stefan F. Helfert and Reinhold Pregla

The method of lines (MoL) [1] has been widely used for the analysis of waveguide structures in optics and microwaves. The wave equation is discretized in the cross–section directions with finite differences and analytic expressions are used in longitudinal direction. In direction of the discretization suitable boundary conditions have to be chosen to model the devices as accurate as possible. Further, the computational window should be as small as possible to keep the numerical effort low enough, allowing e.g. the analysis of various structures within a short time. In case of complicated three–dimensional devices the analysis might even be impossible, otherwise.

Boundary conditions were developed particularly for periodic structures in the cross–section direction. Fig. 1 shows the electric field of the fundamental Floquet–Bloch mode of a photonic crystal. Here, we have a periodic structure in two directions. In longitudinal direction we used the algorithm presented in [3]. The computational window in lateral direction was chosen as 10.5 μm so that the field still has a significant value. The developed boundary conditions were used for treatment of the lateral periodicity. Also shown are results where the field in lateral direction was determined analytically, allowing the modelling of an infinite periodic structure in that direction [4]. As can be seen the "discretized" field is identical to the analytically determined one.

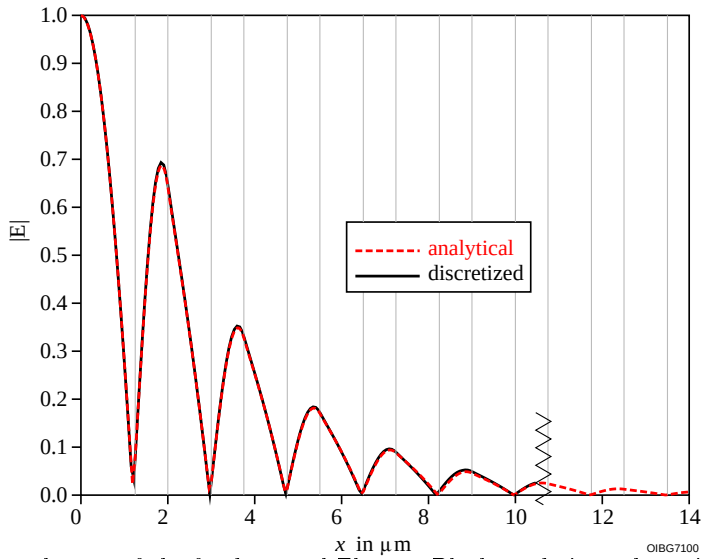

Fig. 1: Electric field distribution of the fundamental Floquet–Bloch mode in a photonic crystal, comparison of the analytically determined field with the one obtained by discretization

[1] R. Pregla and W. Pascher, "The Method of Lines", in *Numerical Techniques for Microwave and Millimeter Wave Passive Structures*, T. Itoh, (Ed.), pp. 381–446. J. Wiley Publ., New York, USA, 1989.

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[3] S. F. Helfert, "Numerical stable determination of Floquet–modes and the application to the computation of band structures", *Opt. Quantum Electron.*, vol. 36, pp. 87–107, 2004, Special Issue on Optical Waveguide Theory and Numerical Modelling.

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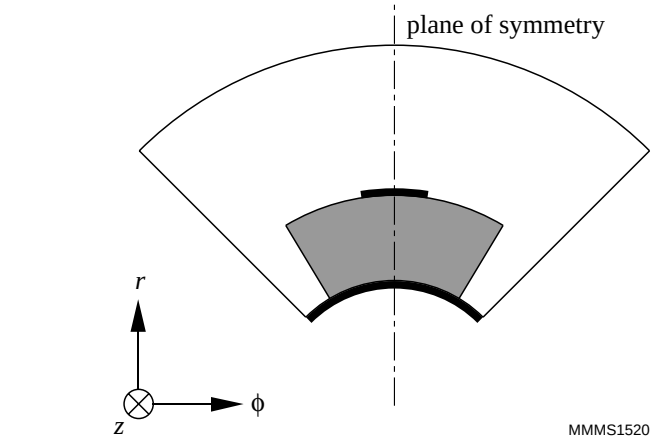
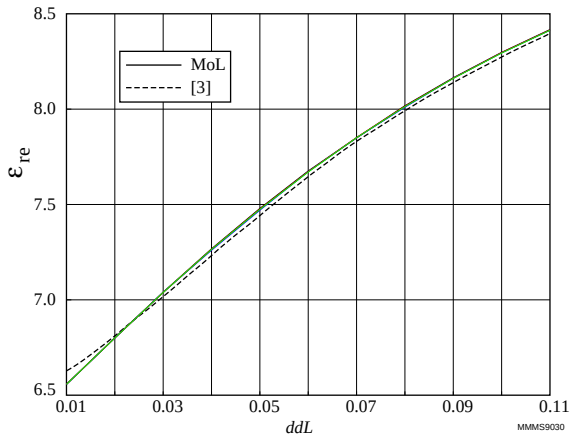
Analysis of circular multilayered waveguide

Agnieszka Barcz, Reinhold Pregla

The Method of Lines (MoL)[1] is an efficient tool for the analysis of various circular waveguides. Under our consideration was a circular multilayered waveguide (Fig. 1a). The presented structure has two layers, substrate is a dielectric with the permittivity equal to 9.7, and the upper region is an air. Two layers are divided by the metallic strip, with the length equal to 1.27mm in ϕ-direction. This circular waveguide was modelled by the Method of Lines in two different ways. First we solved the equation analytically in r-direction by using MoL with Bessel functions [4],[2]. In the second case we analysed the structure by using the MoL with finite differences (linear and quadratic) described by [4]. Because of the symmetry in our computation only half of the structure was used. The results are presented in Fig. 1b.



(a)



(b)

Fig. 1. (a) Scheme of the circular multilayered waveguide , (b) dispersion characteristics obtained by MoL and comparison with results obtained by [3]

The Fig. 1b shows the dispersion characteristics of the examined circular waveguide. As can we see from this picture the results obtained by the MoL with Bessel functions and those obtained by MoL with finite differences (linear and quadratic) are equal to each other. Figure 1b shows us also a comparison with results from [3]. One thing should be mentioned here, the results presented by [3] are for a planar waveguide structure. Therefore results obtained by MoL and results presented by [3] can not cover each other. We can not use infinite radius in our calculations because of the numerical problems. Nevertheless we can say that curve obtained by us is in good agreement with the curve obtained in [3].

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[1] R. Pregla and S. F. Helfert, "Modeling of Microwave devices with the method of lines", in *Recent Research developments in Microwave Theory & Techniques*, B. Beker and Y. Chen, (Eds.), pp. 145–196. Research Signpost, Kerala, India, 2002.

[2] M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, chapter 9, Dover Publ., New York, 1965.

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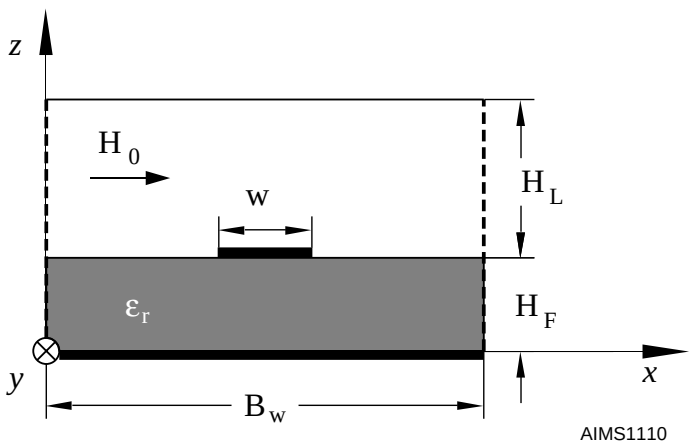
Planar waveguide on the Ferrite Substrate

Agnieszka Barcz, Reinhold Pregla

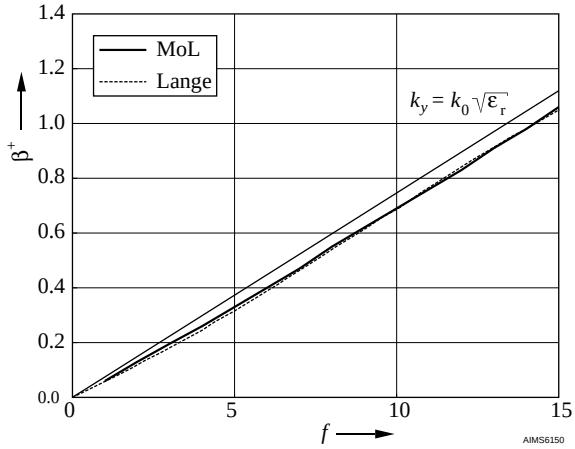
In our work we consider the problem of the electromagnetic field propagation along the microstip covered by air on a transversely magnetized ferrite substrate. The metal strip is infinitely thin, perfectly conducting of width w placed in the middle on the ferrite substrate with the thickness of H_F. The covered layer of the thickness H_L is air-filled. The ferrite substrate is magnetized along the x-axis to saturation magnetization $M_s = 1.71$ kA/cm by external homogeneous DC magnetic field $H_0 = 7.96$ kA/cm. The ferrite material is characterized by the permeability tensor of the form

$$\overleftrightarrow{\mu} = \mu_0 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1+\chi & -j\kappa \\ 0 & j\kappa & 1+\chi \end{bmatrix} \qquad \chi = \frac{\omega_0 \omega_s}{{\omega_0}^2 - \omega^2} \qquad \kappa = \frac{\omega \omega_s}{{\omega_0}^2 - \omega^2} \tag{1}$$

with $\omega_0 = \gamma H_0$ (ferromagnetic resonance angular frequency), $\omega_s = \gamma M_s$ (γ =the gyromagnetic ratio). The cross section of the examined structure is presented in Fig. 1a. The Method of Lines (MoL) [1],[2] was used to investigate the wave propagation along the structure. The obtained results are presented in Fig. 1b.



(a)



(b)

Fig. 1. (a) (a) Cross-section of the examined structure $H_L = 0.4$,$H_F = 0.1$,$B_w = 2$,$w = 0.3$; all dimensions are given in [cm] (b) dispersion characteristics obtained by MoL and comparison with results obtained by [3]

Fig. 1b shows the propagation constant of the fundamental mode and a comparison with results from Lange [3] . The propagation constant of the found fundamental mode does not exceed the limit $ky = k_0\sqrt{\varepsilon}$ as expected. The results obtained by using MoL agree very well with results presented by Lange[3].

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[2] R. Pregla, "Modeling of Optical Waveguide Structures with General Anisotropy in Arbitrary Orthogonal Coordinate Systems", *IEEE J. of Sel. Topics in Quantum Electronics*, vol. 8, pp. 1217–1224, Dec. 2002.

[3] F. J. K. Lange, "Analysis of Shielded Strip- and Slot-Lines on a Ferrite Substrate Transversely Magnetized in the Plane of the Substrate", *AEÜ*, vol. 36, pp. 95–100, 1982.

Numerical Analysis of the Planar Gyrotropic Waveguide

Agnieszka Barcz, Reinhold Pregla

The planar gyrotropic waveguiding structures are very promising structures for modern microwave technique. In our investigations we examined planar gyrotropic waveguides. The metal strip is $0.1cm$ long in the z-direction and is infinite thin in the x-direction. The ferrite substrate is magnetized along the z-axis to saturation magnetization $M_s = 1.4$ kA/cm by an external homogeneous DC magnetic field $H_0 = 2.0$ kA/cm. The ferrite material is characterized by the permeability tensor of the form presented below, where $\omega_0 = \gamma H_0$ (ferromagnetic resonance angular frequency), $\omega_s = \gamma M_s$ (γ =the gyromagnetic ratio).

$$\overleftrightarrow{\mu} = \mu_0 \begin{bmatrix} 1+\chi & -j\kappa & 0 \\ j\kappa & 1+\chi & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad \chi = \frac{\omega_0\omega_s}{{\omega_0}^2 - \omega^2} \qquad \kappa = \frac{\omega\omega_s}{{\omega_0}^2 - \omega^2} \tag{1}$$

The cross section of the examined structure is presented in Fig. 1. For the analysis the method of lines (MoL) ([1],[2])

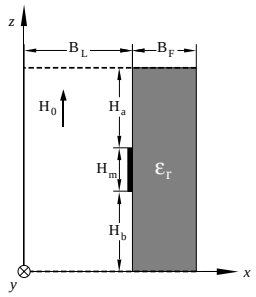
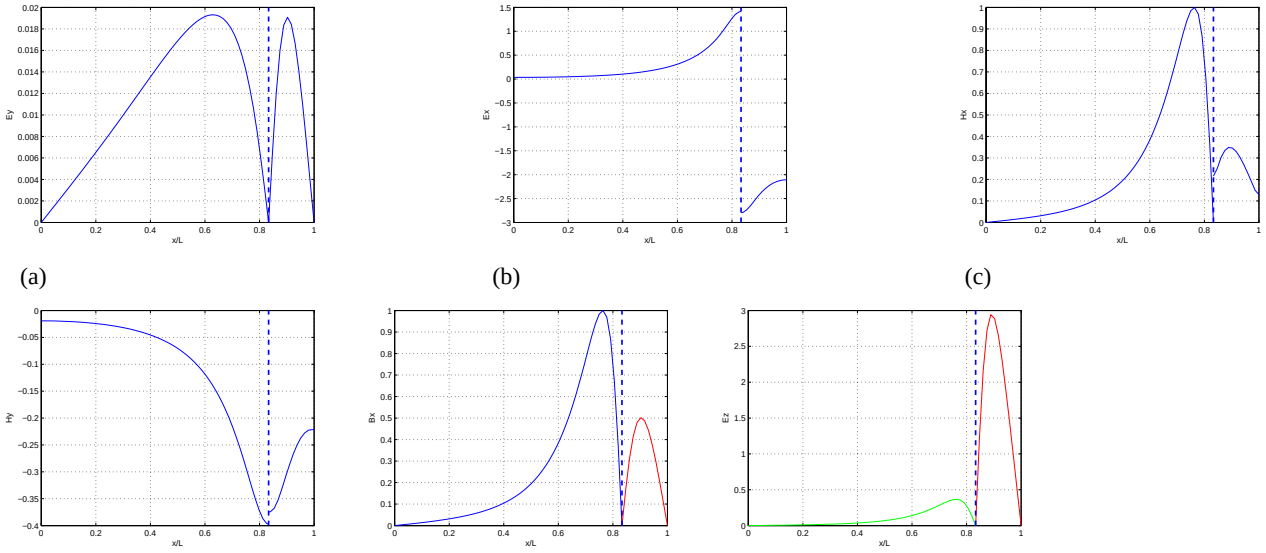


Fig. 1. Cross-section of planar gyrotropic waveguide with magnetization H_0 in z-direction; H_a=H_b=0.3196, H_m=0.1, B_F=0.0635, $B_L = 5 \cdot B_F$; all dimensions are given in [cm]

is used. Obtained results are shown in Fig. 2. The presented field distributions are obtained for the frequency f=8GHz.



(a) (b) (c)

(d) (e) (f)

Fig. 2. Field distribution of: (a)E_y, (b)E_x, (c)H_x, (d)H_y, (e)B_x, (f)E_z

The presented results show that the obtained transversal field components fulfill the boundary conditions [2]. At the boundary of the structure in x-direction we have metallic walls and, as we can see from the picture (Fig. 2a), E_y is decreasing to zero in the microstrip and boundary region. The position of microstrip is marked by dashed lines. Furthermore B_x and Ez shown in Fig. 2e,f, fulfill the boundary conditions as well. The B_x and E_z are computed, according to [2], from the traversal magnetic field components. The other field components E_x, H_y, (Fig. 2b,d) are, as expected, not equal zero in the metal strip area (dashed line). H_x (Fig. 2c), given in air, is decreasing to zero at the boundary (left side) and on the metal strip (right side). The obtained results confirm the algorithm proposed by Pregla in [2].

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[1] R. Pregla and S. F. Helfert, "Modeling of Microwave devices with the method of lines", in *Recent Research developments in Microwave Theory & Techniques*, B. Beker and Y. Chen, (Eds.), pp. 145–196. Research Signpost, Kerala, India, 2002.

[2] R. Pregla, "Modeling of Optical Waveguide Structures with General Anisotropy in Arbitrary Orthogonal Coordinate Systems", *IEEE J. of Sel. Topics in Quantum Electronics*, vol. 8, pp. 1217–1224, Dec. 2002.

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Research activities

- Heterojunction solar cells
- Interaction of hydrogen with silicon
- Radiation hardness of solar cells
- Nanoelectronic devices based on nuclear tracks
- Silicon-on-insulator technology

Admittance Measurements On a-Si/c-Si Heterojunction Solar Cells

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Amorphous silicon/crystalline silicon (a-Si:H/c-Si) solar cells with areas of 1×1 cm^2 are produced by deposition of a-Si:H and indium-tin-oxide (ITO) on a 3" wafer. Three types of samples have been prepared for admittance measurements differing in the way how the effective area is defined. The measurement geometry is either defined by cutting, by etching the ITO layer outside the 1 cm^2 active area or by etching the ITO and the a-Si:H outside the active area.

Admittance measurements reveal that the lateral conductivity of the ITO is high enough up to a frequency of 1 MHz to ensure a lateral equipotential surface. A simple equivalent network consisting of a parallel resistor-capacitor branch in series to a second resistor controls the cut sample. For the sample with just ITO layer etching, the effects of a lateral channel due to the a-Si:H layer have to be included.

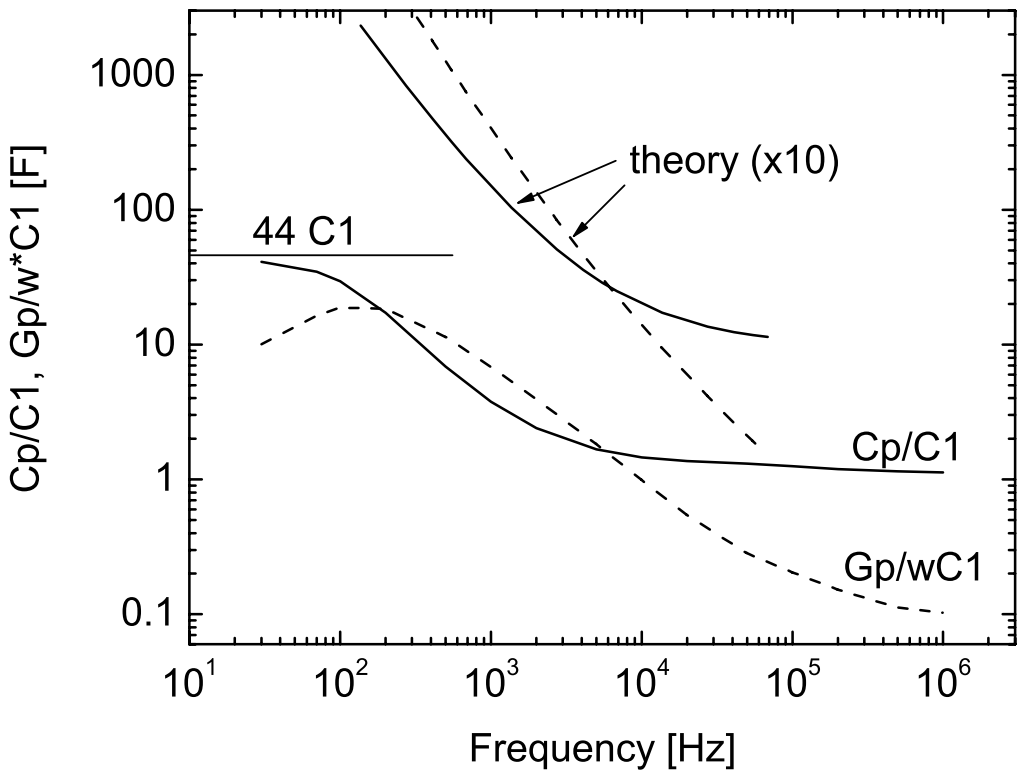

Fig. 1: Admittance dispersion of an a-Si/c-Si solar cell with unsufficient lateral separation

The finite dimensions of the sample modify the low pass character of the channel. The sample with ITO and a-Si:H layer etching delivers the best measurement conditions. In all three cases the dispersion grants that the surface doping level of the substrate can be extracted from the CV characteristics measured at 1 MHz.

Radiation Damage In Amorphous Silicon / Crystalline Silicon Heterojunction Solar Cells

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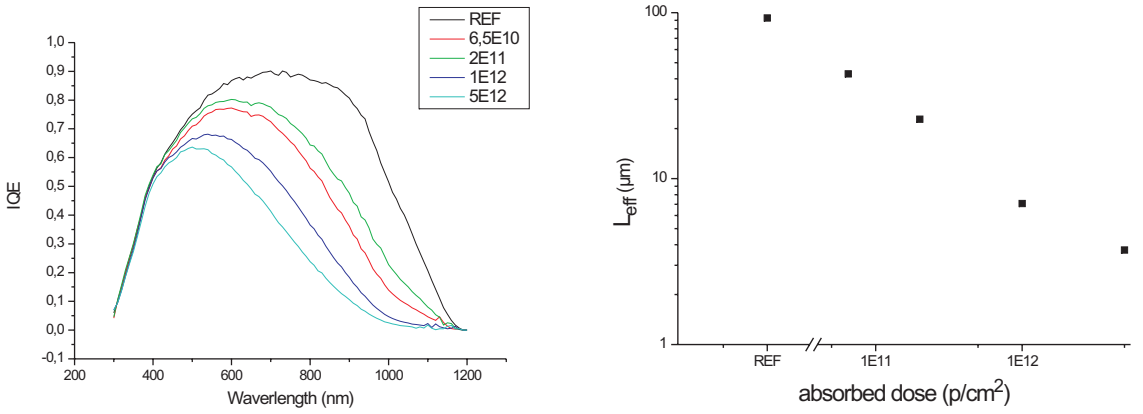
Recently, amorphous silicon / crystalline silicon heterojunction solar cells have gained some interest for their use in space environment. In order to predict their degradation during a mission, the cells were irradiated with protons at various irradiation facilities. Besides the dark and light IV characteristics, the spectral response was measured and the diffusion length, L, was deduced. A plot of $1/L^2$ vs dose delivers the damage constant, k_L. This procedure was repeated for various energies. The obtained damage constants were comparable to those of diffused solar cells [1].

Admittance measurements reveal that the lateral conductivity of the ITO is high enough up to a frequency of 1 MHz to ensure a lateral equipotential surface. A simple equivalent network consisting of a parallel resistor-capacitor branch in series to a second resistor controls the cut sample. For the sample with just ITO layer etching, the effects of a lateral channel due to the a-Si:H layer have to be included.

The finite dimensions of the sample modify the low pass character of the channel. The sample with ITO and a-Si:H layer etching delivers the best measurement conditions. In all three cases the dispersion grants that the surface doping level of the substrate can be extracted from the CV characteristics measured at 1 MHz.



(a) (b)

Fig. 1: Quantum efficiency for samples irradiated at 1.7 MeV and various doses (a), diffusion lengths, L_p, vs. dose, Θ, for samples irradiated at 1.7 MeV and various doses (b)

[1] Y. Tada; J. R. Carter Jr., B. E. Anspaugh, R. G. Downing, *Solar Cell Radiation Handbook*, NASA, JPL, Pasadena, CA 1982.

Hydrogen Gettering in Hydrogen Implanted and Hydrogen Plasma Treated Czochralski Silicon

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The thermal evolution of hydrogen complexes in silicon after a combination of hydrogen implantation and subsequent plasma treatments of p-type Czochralski (Cz) silicon has been investigated. The samples were hydrogen implanted with 1×10^{16} H^+cm^{-2} or 4×10^{16} H^+cm^{-2} at an energy of 40 keV and an ion current of 30-40 μA. Then the samples were plasma hydrogenated with a PECVD system at various substrate temperatures between 20 °C and 270 °C. The RF plasma was applied for 60 min at a frequency of 110 MHz, a RF power of 50 W, a H_2 flow of 200 sccm and a pressure of 400 mTorr. After hydrogenation the samples were annealed at temperatures up to 600 °C in air.

The investigation has been done by μ-Raman spectroscopy (μ-RS). In comparison to thermal treated and just implanted or plasma treated samples, the effects of the combination were analyzed. An increase of the Raman spectra intensity at a frequency of $\approx$3820 cm^{-1} after implantation and subsequent plasma treatment can be ascribed to an accumulation of hydrogen molecules in multi-vacancies. The vacancy complex was not observed after just plasma treatment. In the case of mere plasma treatment, silicon-hydrogen bonds and hydrogen molecules, respectively, were observed at the Raman shifts 2100 cm-1 and $\approx$4150 cm^{-1}. Hence, one can assume that the hydrogen molecules are trapped by these multivacancies. The formation of hydrogen complexes strongly depends on the hydrogenation temperature. At substrate temperatures above 250 °C, an intensification of the Raman peak at $\approx$4150 cm^{-1}, related to hydrogen molecules located in larger voids like platelets or microcavities was observed. Low temperature plasma treatments and post-hydrogenation lead to Raman peak shifting from $\approx$3820 cm^{-1} to $\approx$4150 cm^{-1}. This transformation can be attributed to the variation of the surrounding silicon host matrix of the H_2 molecules, which was previously observed in Si implanted, hydrogenated an annealed float zone silicon samples, and was also detected in only hydrogen implanted and annealed samples. It is well known that the evolution of hydrogen in silicon can cause blistering and exfoliation, which was also observed after a high dose implantation ($> 4 \times 10^{16}$ H^+cm^{-2}) and a subsequent thermal treatment. The hydrogen induced exfoliation is the key to the Smart-Cut process, a process for the silicon on insulator fabrication. Furthermore, other gettering effects of hydrogen in vacancies and the evolution of the vacancy complex were investigated. Therefore, the Raman spectrum from $\approx$1800 cm^{-1} to $\approx$2300 cm^{-1} has been studied. A variation of the vacancy hydrogen complex depending on the post-annealing temperature as well as on the plasma hydrogenation temperature was noted[1].

[1] W. Düngen, R. Job, Y. Ma, Y. L. Huang, W. R. Fahrner, L. O. Keller, and J. T. Horstmann, *Solid State Phenomena* **108-109**, 91(2005)

Thermal Evolution of Hydrogen Related Defects and Void Formation in the Silicon Ion-Cut Process

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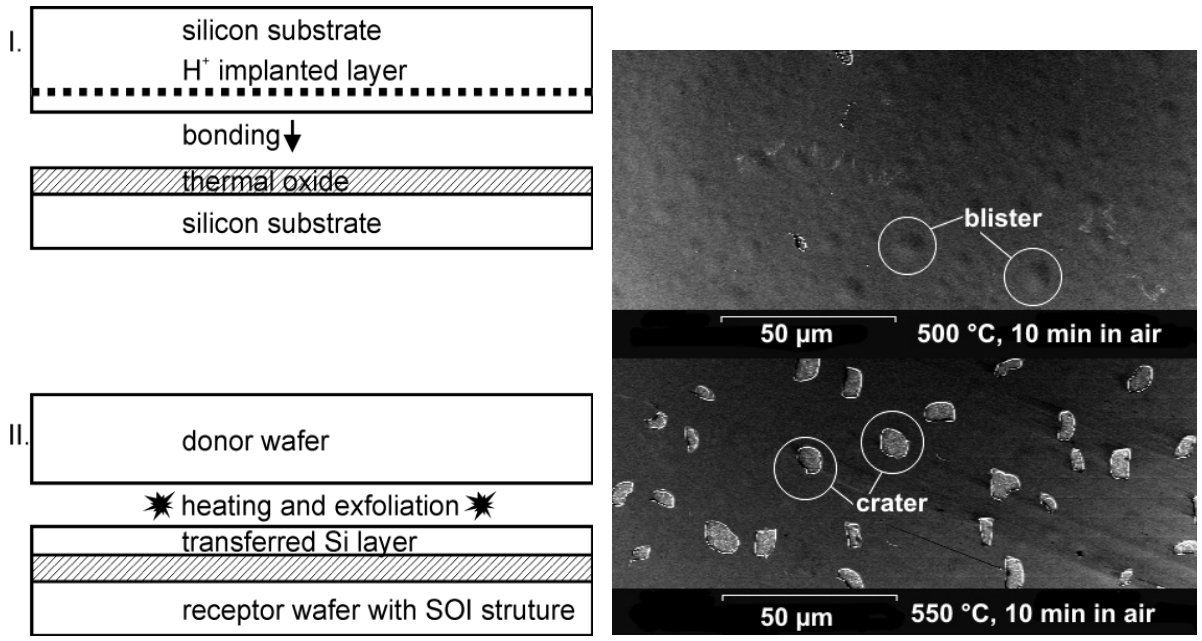
An implanted strong hydrogenous layer in silicon leads to blistering or to exfoliation during annealing at temperatures above 550 °C. This effect is used to create thin silicon layers, i.e. in the commercial Smart Cut© process for silicon on insulator (SOI) fabrication descreibed in figure (a).
In our experiment [1], p-type Cz silicon wafers were implanted at a dose of 4×10^{16} cm^{-2}/H$^+$ and an energy of 50 keV/H$^+$.Post implantation annealing was applied for 10 min in air at various temperatures. The surface was investigated by μ-Raman-Spectroscopy with local focus on bulk silicon, blisters or craters. The blistered surface was analyzed by Scanning electron microscopy (SEM) (figure (b)). After direct bonding on SiO_2 surface and exfoliation by annealing, μ-Raman investigations on various layers after layer transfer and exfoliation were applied.



(a) (b)

Fig. 1: Schema of the silicon ion-cut (a): The silicon layer exfoliates after H$^+$ implantation, substrate bonding and subsequent annealing at 600°C , Scanning electron micrograph of p-type Si after H$^+$-implantation (b) (dose: 4×10^{16} cm^{-2}, energy: 50 keV/H^+), closed blisters (top) and craters (exploded blisters, bottom)

Annealing of H$^+$ implanted Cz-silicon samples leads to a strong modification of hydrogen related defects: The surface starts to blister / exfoliate. Most Raman lines related to the V_xH_y complexes decay. V_2H_6 can be observed in hte surface layer above blisters, in the silicon bulk and on the transferred layer. No hydrogen related defects after the ion-cut on the donor wafer. H_2 molecules are situated in blisters, prior in multi-vacancies. We conclude that during the annealing procedure, H diffuse from multi-vacancies to larger voids, i.e. platelets or blisters and vacancies diffuse and coalesce to large voids, i.e. platelets or blisters.

[1] W. Düngen, R. Job, Y. Ma, Y. L. Huang, W. R. Fahrner, L. O. Keller, and J. T. Horstmann, 2005 *MRS Spring Meeting*, San Francisco, CA, March 28 - April 1

DLTS study on deep levels formed in plasma hydrogenated and subsequently annealed silicon

Y. L. Huang, Y. Ma, W. Düngen, R. Job, and W. R. Fahrner

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Both hydrogen-induced donor and acceptor-like centers have been observed in silicon. The incorporation of hydrogen in shallow thermal donors (STDs) was clearly confirmed by the observation of an isotope shift in Infrared (IR) absorption spectra when hydrogen was replaced by deuterium.

We have investigated the hydrogen-related shallow and deep levels formed in p-type Czochralski (Cz) silicon crystals during low-temperature plasma hydrogenation. Combined capacitance-voltage (C-V), capacitance-temperature (C-T) and deep-level transient spectroscopy (DLTS) measurements have been used to investigate the properties of the hydrogen-related centers.

Samples used in the present work are p-type Cz Si wafers with [B]$\approx 10^{15}$ cm^{-3}. SRP results indicated that a p-n junction was created in the as-plasma treated silicon, revealing the creation of shallow donors (SDs). Note that the hydrogenation temperature, 270 °C is lower than the temperature range for oxygen TD formation. Furthermore, the C-T plots indicate that the hydrogen shallow donors (HSDs) are frozen-out earlier than the oxygen thermal donors (OTDs). It is, therefore, reasonable to propose that these SDs are hydrogen-related, i. e., HSDs. The C-V results (figure 1a) show that annealings at 275 °C (20 min) and 300 °C (30 min) lead to a significant increase of the free carrier concentration in the 12 h hydrogenated silicon.

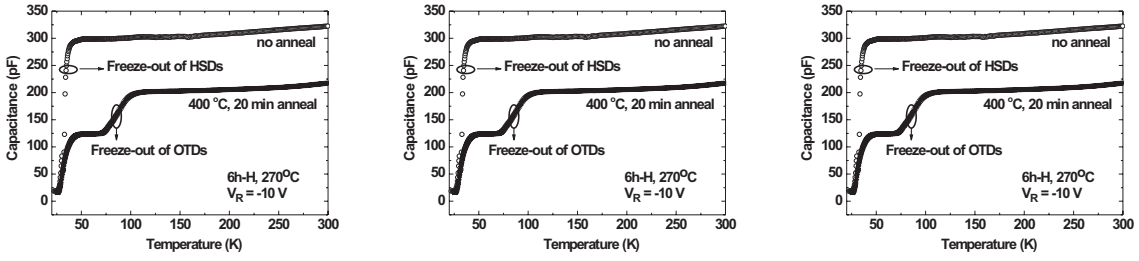

Fig. 1: Free carrier concentration profiles extracted from C-V measurements (a), DLT spectra for 12 h hydrogenated samples with various anneals (b), concentrations of free carriers and deep levels vs. anneal temperature (c)

Figure 1b shows the DLT spectra for the 12 h-hydrogenated Cz silicon. It is found that a DLTS peak occurs around 60 K in the as-hydrogenated samples and after a 300 °C anneal, while another one occurs around 52 K in the sample post-hydrogenation annealed at 400 °C. The latter DLTS peak is in line with the TD peak observed in n-type 450 °C heated Cz silicon. The corresponding trap concentrations derived from DLTS measurements are about one decade lower than the carrier concentration derived from C-V measurements figure 1c, indicating the existence of HSDs which cannot be detected by DLTS [1].

[1] Y. L. Huang, E. Simoen, C. Claeys, Y. Ma, W. Düngen, R. Job, W. R. Fahrner, J. Versuluys, P. Clauws, *Solid State Phenomena* **108-109**, 547 (2005)

Micro-Raman Analysis of Hydrogen Related Defects in Czochralski Silicon

R. Job, W. Düngen, Y. Ma

In frame of the project "Preparation of Silicon-on-Insulator Layers by Ion Implantation at Low Doses and Subsequent Hydrogen Plasma Treatments" (Deutsche Forschungsgemeinschaft, DFG, project no.: JO 297/7) hydrogen related defects were investigated in Czochralski silicon (Cz Si). The properties of the Cz Si wafers can be significantly altered by the incorporation of hydrogen. The hydrogen related impact on Cz Si wafers can be separated into either surface, subsurface or bulk effects depending on the local regions, where the hydrogen caused actions occur. By -Raman spectroscopy (μRS) the formation of hydrogen related defects - including vacancy-hydrogen complexes, hydrogen saturated silicon dangling bonds, H_2 molecules trapped in multi-vacancies or platelets - has been investigated in hydrogen implanted and subsequently plasma hydrogenated and annealed Cz Si wafers. Annealing was done either in air or in forming gas (90% N_2, 10% H_2) ambient. Depth resolved RS was also applied as a useful method for the identification of the various hydrogen related defects in the subsurface regions of the treated wafers.

Due to its high reactivity the impact of hydrogenation by implantation and/or plasma exposure on the wafer properties is manifold. A large variety of hydrogen related defects are created. Concerning ion-cut processes for Si-layer exfoliation with reduced implantation doses (i.e. D $\approx$ 1×10^{16} cm^{-2}), the missing hydrogen concentration for the realization of layer splitting at the buried implantation damage layer during the final annealing step at about 550 °C has to be provided by H-plasma exposure. On this background the series of experimental RS investigations of H-implanted, H-plasma treated and annealed samples provided detailed information about the formation and evolution of various hydrogen related defects - vacancy-hydrogen complexes, V_n-H_m, hydrogen saturated silicon dangling bonds, Si-H_x, H_2 molecules trapped in multi-vacancies or platelets - under low dose process requirements, which are significant for the layer exfoliation (i.e. what we call "soft-cut process conditions").

During H-implantation at a dose of $\approx$ 1×10^{16} cm^{-2} various types of vacancies and Si self-interstitials are formed. H-plasma exposure at $\approx$ 200 °C applied as a second step causes the formation of platelets. In consequence, in H-implanted and subsequently plasma hydrogenated samples both types of defects could be verified by μRS analysis, i.e. on one side vacancy-hydrogen complexes (Raman lines of various V_n-H_m defects around 2100 cm^{-1} and of H_2 molecules trapped in multi-vacancies at $\approx$ 3820 cm^{-1}) and on the other side hydrogen induced platelets could be detected (hydrogen decorated dangling bonds at the internal open surfaces of 100-platelets, i.e. Si-Hx modes around 2100 cm^{-1}, and the Raman mode of H_2 molecules located in platelets at $\approx$ 4150 cm^{-1}). Annealing in forming gas slows down the dissolution of most of the hydrogen related defect species in H-implanted and subsequently H-plasma treated Cz Si. The tendency of hydrogen to diffuse out from the wafer at elevated temperatures is significantly reduced due to the change of the partial pressure if annealing is applied in hydrogen containing ambient. Multi-vacancies could not be detected anymore after annealing in forming gas, but {100}-platelets still are found. The characteristic peak at $\approx$ 4150 cm^{-1} even is somewhat stronger than for the as-implanted/as-plasma treated sample. This indicates that multi-vacancies most probably coalesce and create new platelets or coalesce with already existing platelets. The investigations show that μ-Raman spectroscopy is a useful tool to study hydrogen related defects in silicon. For more details see [1].

[1] R. Job, W. Düngen, Y. Ma, Y. L. Huang, J. T. Horstmann, *Microelectronics Technology and Devices (SBMicro 2005)*, Eds.: C. L. Claeys, J. W. Swart, N. I. Morimoto, P. Verdonck, Electrochemical Society Proceedings **2005-08**, 90 (2005) **(invited)**

Chemical Structuring and Materials Design in the Shells of Modern Brachiopods

R. Job

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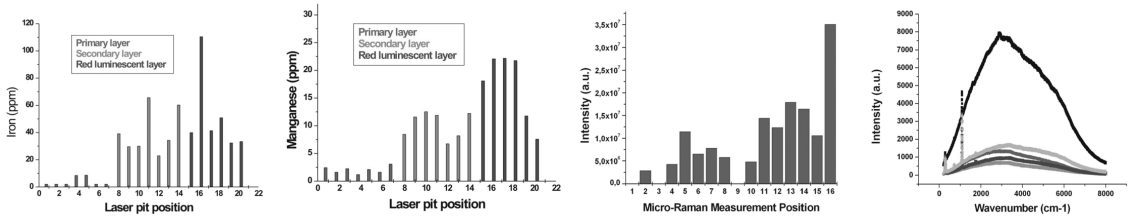
Compositional and structural variations at various scale levels have been investigated in the shells of the modern brachiopod Megerlia truncata combining transmission electron microscopy (TEM), cathodoluminescence (CL), laser-ablation-inductively-coupled-mass-spectrometric (LA-ICP-MS) and micro-Raman spectroscopical (μRS) analyses. Our results show that these shells can be addressed as hierarchically structured, multi-scaled organic/inorganic fiber composites. A significant chemical as well as a mechanical inhomogeneity is observable within the shells. This occurs on various scale levels ranging from less than one to a few hundred microns. In concert to systematic variations in micro- and nanohardness the RS and CL analyses reveal a systematic distribution and incorporation of organic material within the shells, which is negligible within the nanocrystalline primary layer but is present in a significant amount in the innermost part of the secondary layer, next to the organic tissue of the animal. Our study shows that the mechanical



(a) (b) (c) (d)

Fig. 1: Iron (a) and manganese (b) distributions within different sections of the shell together with the distribution of organic material within the shell (c) as deduced from the background luminescence in the Raman spectrum (d). While the intensity of the luminescence is very low in the primary layer, it increases significantly in the organic-rich, red-luminescent shell segment.

performance (hardness and fracture toughness) of this biomaterial is mainly determined by textural features, an extreme variation of crystallite size and a purpose oriented interlinkage of organic and inorganic components. Chemical and structural inhomogeneities are present and relatable to each other in the shells of the modern brachiopod Megerlia truncata. These inhomogeneities occur on various scale levels. The variations predominantly occur in calcite crystallite size, texture, occurance and distribution pattern of organic material between the crystals. The presence and mode of distribution of organic material can easily be detected by the combined interpretation of cathodoluminescence and micro-Raman signals. For more details see [1].

[1] E. Griesshaber, R. Job, K. Kelm, A. Sehrbrock, R. D. Neuser, W. Mader, W. W. Schmahl, *2005 MRS Fall Meeting*, Boston, USA, (Symposium L: "Mechanical Behavior of Biological and Biomimetic Materials")

Hydride Formation On the Platelet Inner Surface of Plasma Hydrogenated Crystalline Silicon Investigated with Raman Spectroscopy

Y. Ma, Y. L. Huang, W. Düngen, R. Job, and W. R. Fahrner

The observation of the platelet formation in hydrogenated crystalline silicon (c-Si) can be traced back to the late 1980's. A number of investigations were then carried out to study the microscopic structure of the platelets and the impact of some parameters such as substrate temperature, post-hydrogenation annealing, disorder, doping type and Fermi-level position on the formation of the platelets in Si. However, most of these investigations were done with remote H-plasma treatments, which were more relevant to the plasma cleaning process from an application point of view. On the other hand, hydrogen is also an important (even dominant in some cases) gas in some plasma sources commercially used in semiconductor industries, such as reactive ion etching and plasma enhanced chemical vapor deposition (PECVD). Little investigation has been done on the platelet formation in c-Si material during these treatments. In this study the hydrogenation was done with a PECVD setup under conditions similar as for a-Si:H or mc-Si:H deposition (with respect to substrate temperature, plasma power, hydrogen gas flux and chamber pressure etc.).

The investigations were carried out on phosphorous-doped [100]-oriented Czochralski Si wafers with a thickness of $\approx 400\ \mu m$, a diameter of 3" and a resistivity of 9-11 Ωcm. H-plasma treatments were done in a PECVD-setup at a frequency of 13.56 MHz, a power of 10 W, a substrate temperature of 260°C, a hydrogen flux of 200 sccm, a pressure of 2000 mTorr, and for various durations. The wafer was directly attached facedown on the top electrode. The wafer and both electrodes were horizontally mounted inside the chamber. The distance between two electrodes was about 1.5 cm. The maximum dimension of the sample was $10 \times 10\ cm^2$. After H-plasma treatment, the samples were cut into $1 \times 1\ cm^2$ pieces, then annealed on a hot stage and/or mechanically beveled with a small angle (about 0.5°). We found that no Si-H bonds or H_2 molecules were formed during the beveling process. Micro-RS was carried out on the beveled surfaces of the samples so that the Raman spectra of different sample depths could be obtained. The method of depth-resolved RS has been successfully demonstrated elsewhere. Its main advantage was that the depth profiles of various Si-H or H_2 species could be distinguished easily due to their different Raman shifts. The excitation of the RS was supplied by an Ar^+ ion laser (488 nm, 40 mW). The spectral range was from 200 to 4600 cm^{-1}, with a resolution limited to $\approx 1\ cm^{-1}$. The spectra were normalized with the c-Si optical phonon line ($\approx 520\ cm^{-1}$).

The hydride formation on the inner surfaces of the platelets in PECVD plasma hydrogenated c-Si materials is investigated with RS. Several Si-H Raman subpeaks at 2065, 2075, 2105, 2120, 2130, and 2140 cm^{-1} are found to be related to the different growth stages of the platelets. Based on the results and discuss, we suggest that the structure is the initial nucleus for the {111} platelet formation. The stretch frequency of SiH located on the inner surfaces of this structure is significantly lower than the one of normal SiH, because of the interaction between the opposite hydrogen atoms. No H_2 molecules are formed inside this structure. This structure is a meta-stable configuration. With longer H-plasma treatments or thermal annealing they grow to platelets with H_2 molecules formed inside. At this stage the inner surfaces of the platelets are quite rough, characterized by the vertical SiH_2 or SiH_3 formation. When more H atoms are trapped inside either by further H-plasma treatments or thermal annealing, the inner surfaces of the platelets become flatter and less defective, represented by the normal SiH_2 formation.[1]

[1] Y. Ma, Y. L. Huang, W. Düngen, R. Job, and W. R. Fahrner, *Phys. Rev. B*, **72**, 085321, (2005).

Dependency of Heterojunction Solar Cell Efficiency on the Indium Tin Oxide Deposition Parameters

M. Scherff, Y. Ma, T. Mueller, W.R. Fahrner

In a-Si:H/c-Si heterojunction solar cells the deposition of the transparent and conductive Indium Tin Oxide (ITO) is a crucial process step. The ITO acts as antireflection coating as well as current collector for the front metal grid. The sheet resistance of the ITO decreases with increasing substrate temperature, while the transparency is kept constant. In addition the transparency increases for temperatures above 200 °C. Thus, with increasing substrate temperatures improved efficiencies are expected. In contrast, at temperatures $>$ 165 °C decreasing efficiencies are observed.

The ITO is deposited by DC magnetron sputtering. The substrate temperature is varied from 25 °C to 260 °C and the DC plasma power from 75 W to 300 W. For each ITO process the deposition rate is determined. The ITO layer thickness used in the solar cells is adjusted to a minimum of reflection (R_{min}) at a wavelength of 600 nm to maintain comparable conditions.

In contrast to the ITO sheet resistances the series resistances RS of the solar cells in-

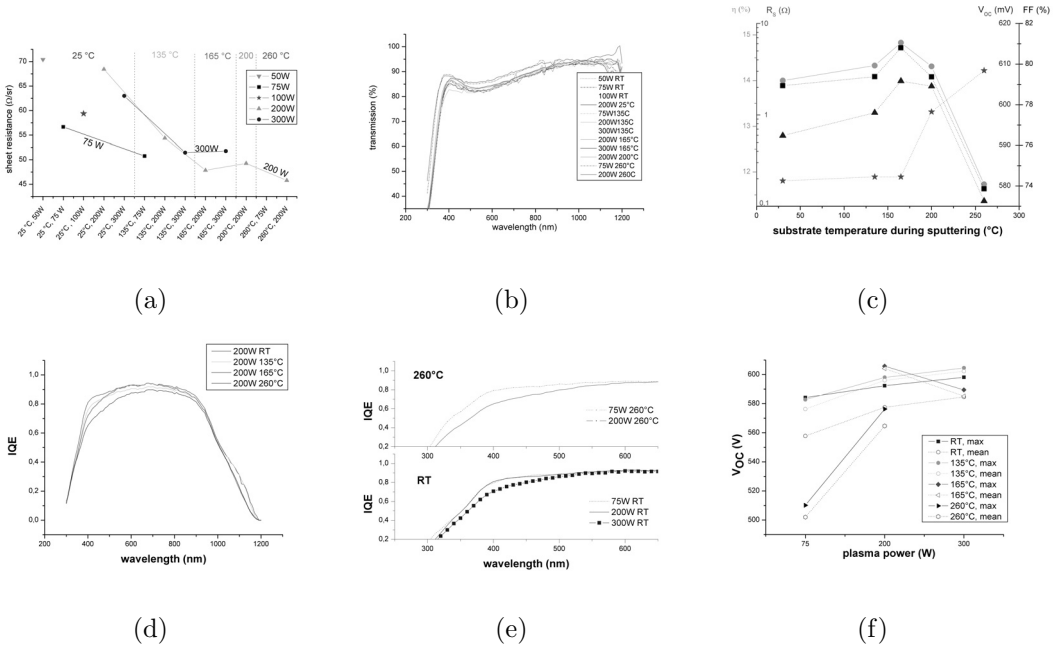


Fig. 1: solar cell characteristics

crease for substrate temperatures higher than 165 °C. As a consequence the open circuit voltage V_{OC}, the fill factor FF and the efficiency h decrease for T>165 C. IQE decreases (350 nm-600 nm) with increasing temperature. Except for the 165 °C process, the solar cells, which are produced with higher plasma power density and shorter deposition time show increased V_{OC} (figure 1f) and higher efficiencies compared to lower plasma power densities. Independent on the ITO deposition temperature the IQE is decreased (350-600 nm) at high plasma power what can be attributed to UV or plasma damage of the amorphous a Si:H emitter.

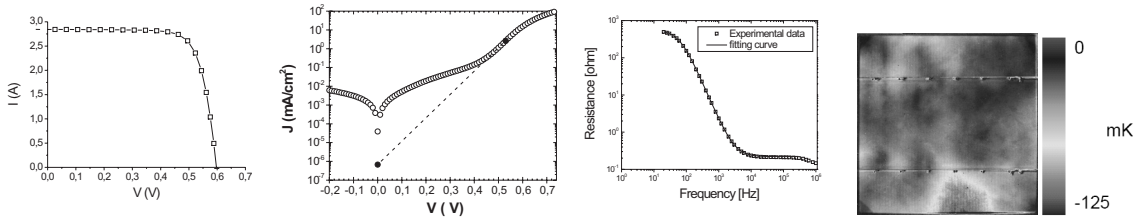
The ITO sputter temperature and plasma power density control the intrinsic optical and electronical ITO layer properties. Apparently improved ITO layers can degrade the a-Si:H / c-Si solar cell characteristics, IQE, V_{OC}, FF, and therefore the efficiency η. Optimum ITO sputter parameters are necessary to deposit highly conductive and transparent ITO layers without degrading the sensitive pn-junction. Highest efficiencies of 15.9 % on textured and 14.8 % on polished c-Si wafers are reached at 200 W RF power and 165 °C substrate temperature.

Electrical Properties of $10 \times 10\ cm^2$ HIT Solar Cells with Screen-Printed Metal Grids Manufactured on Textured P-Type mc-Si Substrates

M. Scherff, Y. Ma, T. Mueller, W. R. Fahrner

Silicon heterojunction solar cells have the potential to be cost-effective devices with higher conversion efficiency. In the last decade solar cells based on amorphous silicon (a-Si:H) / crystalline silicon (c-Si) hetero-structures became important because of their favorable physical properties. One advantage of this technology is the possibility to use only a few nm thin layers to obtain excellent emitters and back surface fields. However, these layers, which are only a few nm thin, are quite sensitive to the subsequent process steps such as deposition of the transparent conductive oxide and firing of the metal contacts. In the present study we have investigated the electrical properties of $10 \times 10\ cm^2$ HIT solar cells with low temperature screen-printed metal grids manufactured on p type mc-Si substrates. The HIT solar cells consist of a grid / ITO / (n)a Si:H / (i)a Si:H / (p)mc-Si / Al structure.

250 μm thick 1-2 Ωcm p-type $10 \times 10\ cm^2$ mc-Si wafers were used as substrates. After saw damage etching the Wafers are hydrogenated to passivate bulk defects. The pn-junction was formed in a standard PECVD setup at 13.56 MHz. at 230°C. 80 nm Indium Tin Oxide is deposited by DC magnetron sputtering. The front side metallization was prepared by screen printing a modified silver paste. A blanket Al layer was evaporated as back contact. No BSF or phosphorous gettering was applied. To investigate the properties



(a) (b) (c) (d)

Fig. 1: solar cell characteristics

of the prepared solar cells I-V (figure 1a and 1b) and C-V figure 1c) measurements are employed to characterize the cell parameters and the interface properties. Thermography (figure 1d) is used to control the emitter thickness and quality. The parallel resistance is somewhat too low as compared to smaller $1 \times 1\ cm^2$ solar cells prepared with similar techniques. This is due to the leakage current at the edge of the $10 \times 10\ cm^2$ solar cells. In the thermograph, a higher temperature area indicates a higher current density. There are no local shunts visible on the entire active cell area but at the cell edge. This is due to an unintentional ITO/a-Si:H and Al deposition on the sample edge so that local shunt is formed between the front and back sides of the sample. $10 \times 10\ cm^2$ HIT solar cells are

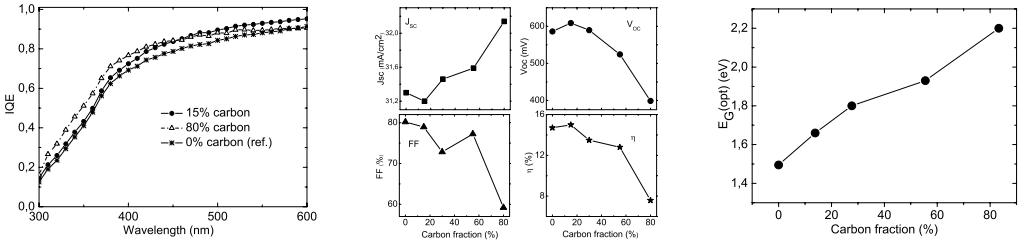
601-04	η [%]	FF [%]	P_{mpp} $[W]$	V_{OC} $[V]$	I_{SC} $[A]$
STC	12.93	76.1	1.29	0.597	2.85
	n-Diode	I_0 $[mA/cm^2]$	R_S $[\Omega]$	R_{SH} $[\Omega]$	
Dark $I-V$	1.36	6.72×10^{-7}	0.024	276.0	

prepared on mc-Si substrates. Efficiencies of up to 12.9% are achieved though no BSF and high temperature getter treatments are applied. Local shunts are observed by means of thermography only at the cell edge even with thin emitters. By avoiding this problem the parallel resistance and FF can be further increased.

Efficiency improvement of HIT solar cells by adding carbon in the emitter

T. Mueller, Y. L. Huang, M. L. D. Scherff and W. R. Fahrner

It is known that the absorption in the emitter layer of a HIT solar cell will lead to a considerable current loss due to the high recombination in this layer. Therefore, it is necessary to suppress absorption in the window layer in order to improve the efficiency of the solar cells. One direct method is to widen the optical bandgap by adding carbon into the emitter of the hetero-junction solar cell. This can be reached via the decomposition of silane (SiH_4) and methane (CH_4). A hydrogenated amorphous silicon carbide (a-SiC:H) with a proper valency control can be used as a wide bandgap window layer for the a-Si hetero-junction solar cells with a high efficiency. We investigate the effect of the emitter layer, a-SiC:H(n), on the performance of a-SiC:H(n)/a-Si:H(i)/c-Si(p) HIT solar cells. Therefore, HIT solar cells were prepared with a structure consisting of Ag grid / TCO / a-SiC:H(n) / a-Si:H(i) / c-Si(p) / Al. Figure 1a shows the internal quantum efficiency



(a) (b) (c)

Fig. 1: IQE vs. wavelength as a function of carbon fraction in the emitter layer (a), J_{SC}, V_{OC}, FF, and h vs. carbon fraction in the emitter layer of HIT solar cells (b), optical bandgap E_G of amorphous emitter layer as a function of the carbon fraction (c)

(IQE) versus wavelength measured for the HIT solar cells with different carbon contents in the emitter layer. It is shown that the spectral response in the short wavelength range increases with increasing carbon fraction of the emitter layer. The effective diffusion length, deduced from the long wavelength range (880 nm-970 nm) is constant for all samples (250 mm). Figure 1b shows the short circuit current density (J_{SC}), the open circuit voltage (V_{OC}), the fill factor (FF), and the efficiency (η) of the HIT solar cells, as the functions of the carbon fraction in the emitter layer. It is indicated by the results that J_{SC} increases slightly with increasing carbon fraction. This result is in line with the trend of the IQE shown in figure 1a. In comparison, VOC and h reach their maximum at a carbon concentration of 15%. A carbon concentration higher than 15% leads to a strong reduction of V_{OC} and η. The significant decrease of FF is attributed to the increase of the series resistance of the solar cell (0.5 to 8 W) with increasing carbon concentration. Spectroscopic ellipsometry has been used to determine the thickness of the emitter layers, the refractive index n, and the extinction coefficient k. The extinction coefficient is a function of the absorption coefficient $\alpha \cdot \hbar = \frac{4 \cdot \pi \cdot k}{\lambda}$ In turn, the optical bandgaps of the emitter layers can be deduced from the Tauc-plot using the following equation $[\hbar \cdot \omega \cdot \alpha \cdot (\hbar \cdot \omega)]^{0.5} = A'(\hbar \cdot \omega E_G)$. Here E_G is the optical bandgap, $\hbar$ is the photon energy and A' is a constant. In this work, the optical bandgaps of the emitter layers are determined by the intercept of $(a \cdot \hbar)^{0.5}$ versus $\hbar$ curve in the high absorption region ($a > 10^4/cm$). The obtained optical bandgaps for the various emitter layers are plotted in figure 1c as a function of the carbon fraction. It is found that the optical bandgap of the phosphorous doped a-SiC:H(n) layers increases monotonically from 1.5 eV to 2.2 eV as the carbon fraction is increased from 0% to 80%. This result is in line with the increase of J_{SC} with increasing carbon concentration.

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Research Areas

Distributed Systems and Software Engineering

- service-oriented computing
- component-based software engineering, in particular architectural design and compositional reasoning,
- component evolution and versioning.

E-Learning Tools and Environments:

- component-based content authoring
- learning with mobile devices
- reusable learning objects
- group formation and recommendation software

Distributed Systems Management

Service-Oriented Computing

Bernd J. Krämer

Service-Oriented Computing (SOC) utilizes services as the lightweight constructs to support the development of rapid, low-cost and easy composition of distributed applications. The visionary promise of SOC is a world of cooperating services where application components are assembled with little effort into a network of services that can be loosely coupled to create dynamic business processes and agile applications that span organizations and computing platforms. Since services may be offered by different enterprises and communicate over the Internet, they provide a distributed computing infrastructure for both intra- and cross-enterprise application integration and collaboration.

SOC is changing the way software applications are designed, architected, delivered and consumed. Services are autonomous platform-independent computational elements that can be described, published, discovered, programmed, and orchestrated to loosely coupled applications using standard protocols for the purpose of building agile networks of collaborating business applications distributed within and across organizational boundaries. Services perform functions that can be anything from simple requests to complicated business processes. This "service-oriented" approach is independent of specific programming languages or operating systems. It allows organizations to expose their core competencies programmatically over the Internet or a variety of networks, e.g., cable, UMTS, XDSL, Bluetooth, etc., using standard (XML-based) languages and protocols, and is implemented via a self-describing interface based on open standards.

Current web service technology largely focuses on messaging mechanisms, semantically poor service representation languages and static service composition mechanisms. Current service-oriented architectures provide the basic operations necessary to describe, publish, find and invoke services. However, for services to be used widely, there is additional functionality that must be considered for service composability including specifications regarding the dynamic composition of services, transactional context and coordination, adaptability to varying circumstances, security and service management.

To overcome the present fragmentation of research efforts in the area of service-oriented computing, we organized an International Dagstuhl Seminar on Service-Oriented Computing in October 2005 [1]. Its objectives were to find common ground in the form of a joint research agenda, sketch a technical road map capturing the state of the art in SOC research and identify opportunities for conducting joint research. Starting point of the road map construction process will be the service-oriented architecture (SOA) drafted by Papazoglou and Georgakopoulos in [2]. This 3-tier SOA extends basic service functionality — as exemplified by the conventional SOA — to support service composition and service management. The extended SOA suggests a logical separation of basic service capabilities provided by the conventional SOA (for example, building simple applications) from more advanced service functionality (for example, composing services on the fly), and from the management of services (for example, managing service compositions). During the seminar an anthology on service- oriented computing has been outlined with chapters being contributed from seminar participants and other experts in the field.

[1] F. Casati, F. Cubera, B.J. Krämer, and M.P. Papazoglou: Dagstuhl Seminar Proceedings 05462, http://drops.dagstuhl.de/portals/index.php?semnr=005462

[2] M.P. Papazoglou and D. Georgakopoulos: Service-Oriented Computing, Communications of the ACM, 46(10):25–28, Oct. 2003

Learning with the Aid of Mobile Devices

Bernd J. Krämer

The wireless Internet stretches the concept of self-paced learning towards anywhere-anytime learning. It provides options to support the seamless continuation of interaction with learning resources and services even when a student is away from the desktop PC. There is, however, much doubt about the use of omnipresent ICT devices like cellular phones for pedagogically valuable learning settings.

As more than 78% of our students own a cellular phone, this project set out to explore ways that enable students to use idle periods, such as travel time with public transportation or waiting time before a meeting, for learning. The major challenge is to design pedagogically valuable learning objects, training activities and support services for use with small mobile ICT devices that are omnipresent in a student's daily life. The focus of this project was on the design of content and learning activities that support spontaneous short learning phases that may attract the student's attention even under noisy conditions. We dveloped Histobrick [1], a game-like application on descriptive statistics, under the assumptions that: a) students use their mobile device particularly for spontaneous, short study phases; b) mobile devices are typically used for repetition, for examination preparation or for quickly looking up details when knowledge gaps are detected in the process of testing the learning progress; c) deep learning has taken place before accessing mobile versions of learning materials, i.e., students have a basic understanding of the learning content they deal with on the mobile device. The learning application was further inspired by recent ideas about learning in constructivist settings and the findings of game-based learning. The latter tries to help learners build stronger intuitions for domain concepts based on perceptual experiences in a virtual environment. In the design of Histobrick we were guided by the following recommendations we drew from our previous project on m-learning challenges and a decent literature study: a) design mainly for off-line usage to minimize connection costs; b) design for single-hand operation to minimize the impact of bumpy conditions during transportation; c) restrict the presentation area to fit entirely on the screen of cellular phones; d) provide interactive learning objects in a platform independent programming language; e) use a game-like scenario to capture a student's attention even in distracting environments; f) aim to support shallow learning and focus on exercises that may reinforce previously learned knowledge. The application was implemented in J2ME (Java 2 Micro Edition). J2ME applications, called MIDlets, are developed and tested on a PC prior to them deploying to real phones.

While developing and deploying early versions of Histobrick, the findings and opinions of a few mobile learning students, who acted as early test students, were taken into account in the ongoing design process. But it is definitely beyond the scope of the work reported here to evaluate the effect of using Histobrick on students' knowledge of statistics. As the technical pre-tests revealed that current mobile phones cannot be reliably integrated into current learning management systems and formal assessment appears to be a task unsuitable for mobile students, the focus of the post-test evaluation set out to collect opinions about general and project specific issues in mobile learning. For this purpose a self-administered, web-based questionnaire was used. The primary purpose of the evaluation we performed with a small sample of students was to understand the modalities in using mobile phones in deepening and testing students' knowledge of a particular field of science (here statistics) by means of an edutainment solution. It also served to investigate the students' acceptance of our prototype solution HistoBrick.

[1] B.J. Krämer: Exploring the Use of Cellular Phones for Pervasive eLearning, IEEE Workshop on Pervasive eLearning, Pisa, March 2006.

Contract Based Testing of Web Services

Michael Averstegge

As Web services become more prevalent the inherent paradigm of loose coupling causes extra effort in testing. Context and enclosing process are not predictable and therefor not solely testable at design time, e.g. a Web service can be a substitute of any unavailable Web service.

Since web services act as black boxes, contracts are the only formal functional specification visible to the client beyond the mere syntactic level offered by WSDL specification.

In order to enable efficient pre-runtime tests, an overall contract for a dynamically created process must be deducable automatically out of the contracts of the atomic Web services. If possible, this can only be done by an additive test layer wrapped around the Web services. Therefore the test is an extra layer acting as testdriver and constraint solver.

We are currently investigating the feasability of creating an overall contract for a service composition based on the contracts of atomic Web services and testing them on the process level.

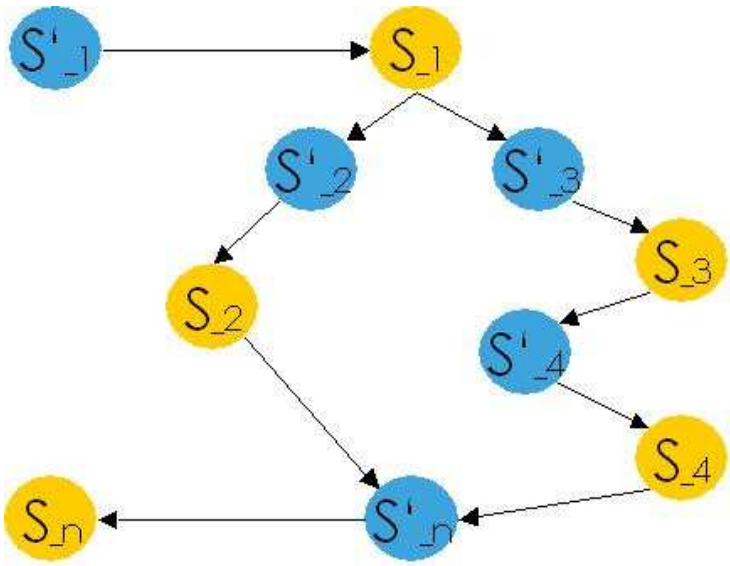

Figure 1: Test layer architecture for contract based black-box testing.

The constructed test layer $T := (S'_1, S'_2, \ldots, S'_n)$ not only executes the test cases but also monitors the input and output parameters of the invoked web service operations $S_1, S_2, \ldots, S_n$, whereby any S'_i acts as a functional proxy for S_i. It holds for each function f'_{i_j} invoced on S'_i: f'_{i_j} is semantical equivalent to its corresponding function f_{i_j} of S_i. f'_{i_j} wrappes f_{i_j} with extra test specific functionality implemented, e.g. checking pre- and postconditions of the contracts c_{i_j} of function f_{i_j}. The test proxy will also be used to monitor and log calls to the service at production time. Based on the evaluated proof on contracts the logged data can be used for test cases. Furthermore non functional properties can be proofed. Extra functionalities (e.g. provider specific exception handling) can be implemented afterwards in the wrapper code of f'_{i_j} using the visitor design pattern.

CampusContent - a research project to support reusability of learning objects

Timo Borst

CampusContent [1] is a research project, which has been established in March 2005. Its focus is to develop a competence centre for collecting, providing and reusing digital resources for online teaching and learning.

In recent years, a lot of high-value learning resources have been developed and used in e-learning. Nevertheless, these resources suffer from being reusable in different contexts and for different purposes. Either, this kind of learning material only contains information provided to the uninstructed learner, or it is too contextual in the sense of presenting complete units of learning like courses adapted to a specific style and layout. CampusContent wants to overcome this dilemma by introducing the notion of a context-independent, self-containing information object, which is associated with a learning objective and corresponding learning activities to become a learning object. Moreover, the use of these learning objects should be motivated by providing learning scenarios to identify its content-related parts.

Seen from a technological point of view, CampusContent aims at developing a infrastructure for managing and sharing learning objects more efficiently than existing repositories. While these repositories or portal-sites in many cases only refer to existing material being described by some metadata, CampusContent follows a user-centered approach considering not only the static properties of content, but also its semantic properties resulting from re-contextualization. In this sense, content is (re-)used

- in a given learning context (e.g. an **online course**),
- in a specific topic (e.g. in **computer science**),
- with a particular rhetorical meaning (e.g. as a **definition**, an **exercise** or an **introduction**),
- in **association** with other content (e.g. an exercise depending on an explanation and an example),
- together with a certain **learning objective** with regard to a certain topic and level of competence (e.g. "To be able to apply the concept of class in object-oriented programming"), and
- with certain **instructions** or activity recommendations to support the learning goal (e.g. "Read the introduction, study the example and exercise the concept of class in object-oriented programming").

Moreover, we investigate the dynamic properties of content, which are subject to its use by - generally speaking - different people and on different occasions. This means that our framework will be designed to track the (re-)use of content with regard to the enumerated semantic properties resp. the learning outcomes resulting from a certain learning sequence being structured by a learning scenario.

[1] http://www.campuscontent.de

Distributed Systems Management in Dynamic Environment

Jianguo Ding

In distributed systems of realistic size and complexity, managers have to face the unstable, uncertain and incomplete information and dynamic updates of management objects and their dependencies among each other. We used Bayesian Networks to represent the knowledge about managed objects and their dependencies and apply probabilistic reasoning to determine the causes of failures or errors [1].

However, dynamic updates bring up even more challenges in fault detection. Dynamic updates in distributed systems can be classified as either hard or soft changes. A hard change means that the change happens abruptly and most of the time a hard-change is generated on purpose by the system owner. While soft changes mean that a change happens gradually and depends on the system history. A soft change typically results from changes of system properties such as performance degradation, application degeneration, or dependency modification. From the experience of systems management, lots of unknown or un-located causes of faults are triggered by a soft change, which is related to the potential changes and updates of the system. Compared with a hard change, a soft-change keeps going on all the time in distributed systems and it is hard to predict by straight-forward approach.

In order to model the dynamic changes in distributed systems, temporal extensions of Bayesian Networks are employed to integrate the time dimension and further to present the prediction strategies based on backward inference in fault management in dynamic environment of distributed systems [2].

Dynamic Bayesian Networks can be considered as time related function. For a soft change, dynamic changes only happen in individual components and on the dependency between components. In Dynamic Bayesian network, the following prediction tasks are to be considered in face of the management requirement.

(1) Prediction per individual component. The state of an individual component in a distributed system can change over time because of the degradation or improvement of the component.

(2) Prediction of the dependency relationship between components. The modification of dependencies between managed objects derives from updating the system performance and changes in the correlation between objects.

(3) Prediction for potential faults based on backward inference. When the future state of the effect nodes is estimated, a promising prediction is to trace the causal nodes based on the estimated state of the effect nodes.

Since the dynamic changes in distributed systems are identified as nonlinear time series, the Least Squares Fit of a polynomial is applied for nonlinear regression [3].

The inference and prediction approaches in dynamic environment can act as an effective mechanism in diagnosis, ranking possible failures, handling of multiple simultaneous failures, and robustness by probabilistic reasoning and demonstrate a more optimal fault detection rate than random detection or exhaustive detection.

[1] J. Ding, B. Krämer, Y. Bai, H. Chen. Probabilistic Inference for Network Management. Universal Multiservice Networks, LNCS: 3262, pages 498-507, 2004.

[2] J. Ding, B. Krämer, S. Xu, H. Chen, Y. Bai. Predictive Fault Management in the Dynamic Environment of IP Networks. Proceedings of 2004 IEEE International Workshop on IP Operations & Management. pages 233-239, 2004.

[3] A. S. Weigend, and N. A. Gershenfeld. Time Series Prediction. Addison-Wesley, 1994.

Highly Interactive Learning Materials

Olaf Nowaczyk

Learning is a process of acquiring information, attaining skills and employing strategies. While the major learning medium is still text, there are more sophisticated forms of learning materials available using digital media. On issues like theoretical informatics and engineering the students have to deal with complex models in their graphical and formal representation. The practice of teaching shows that especially for visual conceptualization, both for static and dynamic processes, the use of animation and simulation programs can be a good extension to the classical text-based method. Beyond the well known multimedia, a new kind of highly interactive learning application, the so called explorations, has been developed in recent years. Explorations allow students to graphically create their own constructions; a program simultaneously translates the constructions into a mathematical description and numerically simulates them. The basic idea behind explorations was to support learning by constructing and providing an immediate system response. The necessary calculations where executed automatically and displayed in graphs and analytic equations. This kind of multi-level representation demonstrates the dependencies that describe the system. Thus, different points of view can be developed for a single task and set in correlation to one other to help the student in gaining a deeper understanding of the topic.

The taxonomy by Anderson and Krathwohl states that creating is the highest level of the cognitive process dimension. It includes all other cognitive processes in learning activities like analyze, understand and remember (cp. [1]). According to an analysis of learning resources using Anderson and Krathwohls cognitive process taxonomy (cp. [2]) less than 2% of all learning resources in the famous Merlot repository (http://www.merlot.org) fulfilled the criteria for the topmost level “create”. Since learning resources of the topmost level are so rare, the explorations, which allow the graphical creation of models, became valuable candidates for reuse. Therefore, they are excellent examination objects for proving methods and techniques to make multimedia resources reusable. Designed as modular units, a single exploration always covers one well-defined topic. It was not the aim to create an entire multimedia script, but rather a few modules, which cover significant topics and are usable in a highly interactive way. The ambitious concepts of the explorations were fulfilled in a couple of applications, which have been developed for fundamental topics in mechanics (including statics, dynamics and failure theories) and theoretical informatics (like deterministic finite automaton and traversing of binary trees). The newest improvement is a framework and a working prototype which support collaborative features like distributed design and awareness over a network. The drawings are synchronized using a server, which as well offers a document management to hand out exercises and to collect the solutions. A distributed learning group can now work simultaneously on one construction that is synchronized by a collaborative-server and calculated, simulated and visualized on each local desktop computer. Our further research goal is to examine how likely these applications could be reused in different learning environments, adapted to altered learning scenarios and combined with additional learning objectives.

[1] Anderson, Lorin W.; Krathwohl, David R. [Eds.] (2001). A Taxonomy For Learning. Teaching, And Assessing: A Revision of Bloom’s Taxonomy of Educational Objectives. New York: Addison Wesley Longman, 2001.

[2] Heyer, Susanne (2005). An Analysis of Learning Resources Using a Cognitive Process Taxonomy. In: M. E. Auer, U. Auer and R. Mittermeir (eds.): International Conference Interactive Computer Aided Learning 2005: Ambient and Mobile Learning. Kassel: Kassel University Press, 2005.

Distributed Recommendation Algorithms in Open Environment

Peng Han

The drastic increase of online resources and services has put an urgent requirement for effective methods to help people choose from the candidates based on the quality and their own preferences. While collaborative filtering (CF) [1] has proved to be an effective personalized recommendation scheme, the traditional centralized algorithms architecture are believed to unable to accommodate the large-scale and distributed characteristics of nowadays web applications in open environment.

Basically, there are two main challenges: scalability and sparsity. The first problem has been caused by the calculation of inter-user similarity. As the user records expand, its complexity will increase quickly. In our approach, we first propose an efficient distributed user profile management scheme based on the distributed hash table (DHT) method, which is one of the most popular and effective routing algorithm in Peer-to-Peer (P2P) overlay network. Then, we present a heuristic neighbor searching algorithm to locate potential neighbors of the active users. Based on that, we have succeeded in distributing the complex calculation task to the peers in the network so as to reduce the burden of each peer. The advantages of our approaches include first the $logN$ neighbor location time, where N is the total number of peers in the network. Second, for each recommendation the network traffic and calculation complexity caused is almost constant with the scale of the system. Based on the evaluation on the EachMovie dataset, we prove that the scalability of our approach has overperformed the traditional centralized ones while achieving preferable performance at the same time.

As the scale of web applications becomes larger and larger, which often has a item set size of millions, even the user seems to rate a relative number of items in the database, the overlap between him and other users are still quite low, which in sequence make the calculation of similarity difficult and less reliable. This is called the sparsity problem in CF research. In order to address this problem, we present an adaptive spreading activation scheme which provides a more intuitive and effective framework for CF based recommendation.[2] The contribution of our work is twofold. First, we make a in-depth comparison and analysis between SA and existing similarity metrics and then introduce the concept of Rating Similarity Matrix (RSM) and Rating Similarity Aggregation (RSA) as a new user similarity metrics. Based on them, we provide a generalized similarity spreading scheme which could deal well with both the binary (transaction) and the numeric ratings. Second, we present an iterative algorithm to learn the RSM automatically from observed ratings. This algorithm provides us with an objective metrics to evaluate the contribution of ratings on different items to the user similarity calculations and make the activation process more adaptive and effective. The experimental result on EachMovie dataset shows that our method succeeds in relieving the the effect of over activation and outperforms the existing algorithms on both dealing with the sparse and dense dataset.

The future work may focus on how to integrate more sophisticated user profiling scheme and corresponding matchmaking method into our distributed recommendation algorithm framework.

[1] J. Breese, Heckerman D., and C. Kadie. Empirical analysis of predictive algorithms for collaborative fitering. In Proceedings of 14th Conference on Uncertainty in Artificial Intelligence, pages 43-52, 1998.

[2] P. Han, B. Xie, F. Yang, Ruimin Shen. An Adaptive Spreading Activation Scheme for Performing More Effective Collaborative Recommendation. DEXA2005 95-104

Mobile learning using handheld devices

Georg Ströhlein

We extended e-learning to m-learning by providing students with learning material on handheld devices like mobile phones and personal digital assistants (PDAs), respectively.

Figure 1: Different kinds of learning material as displayed on handheld devices.

In case of mobile phones, the mobile version of the Java platform (J2ME) was harnessed to create an interactive, game-like learning object [1] concerned with some concepts of descriptive statistics. The output entirely fits on a phone's screen (see Fig. 1a), and no extensive text input is required. In order to establish collaborative work as well as tutoring, the so-called Java MIDlet allows to upload own problems to a web server as well as to download problems uploaded by others. In case of PDAs, add-ons [2] to a standard course taught at FeU were developed, i.e. a mobile version of the course itself (see Fig. 1b), a glossary (see Fig. 1c), and a pool of self-administered exercises (see Fig. 1d). In order to serve different operating systems of current PDAs, the material was provided in Palm database, Microsoft Reader eBook, and HTML format. The latter format can be viewed on mobile phones as well (see Fig. 1c,d). The complexity of the navigation elements as well as graphics used in the standard course had to be considerably reduced for the sake of usability. Because only few phones support the latest J2ME version which natively supports calculations with fractional numbers, even some didactical aims had to be dropped. FernUniversität's FuXML system could not be modified easily to allow for handheld gadgets as output devices. Whereas even longer texts can be read conveniently from a PDA's screen, reading German text (long nouns!) using mobile phones is a burden. Unfortunately, there is no software for automatically using the shy-HTML entity for syllabification.

Communicating via email is no problem when using PDAs. Contrary, accessing FernUniversität's webmail system using mobile phones that are only WAP enabled causes severe problems because FernUniversität's certificates are not recognised by WAP gateways of most mobile services providers. In case of these phones, problems also occurred when accessing a web server from within J2ME. But all these effects fortunately disappear when using mobile phones natively supporting the HTTP protocol.

Concluding, mobile learning now is in a stage where it is neither completely hype nor completely tripe but can be seen as a service delivered by student-oriented education institutions to support their students.

[1] Georg Ströhlein: Using Mobile Phones for Mobile Learning,
http://learning.ericsson.net/mlearning2/files/workpackage8/feu_evalhistrobrick.pdf

[2] Bernd J. Krämer: FernUniversität's Contributions to the 2nd Year of the Project,
http://learning.ericsson.net/mlearning2/files/workpackage4/feu_technical_working_paper_2.pdf

Safe Updates in Component-based Software Systems

Alexander Stuckenholz

The paradigm of component-based software development (cbsd) is characerized by the planned integration of preproduced software components, by modular architectures and service orientation. Like any other software engineering paradigm, the main aim is to reduce the complexity of software development by increasing the level of abstraction, to shorten the time-to-market and increase the quality of the product.

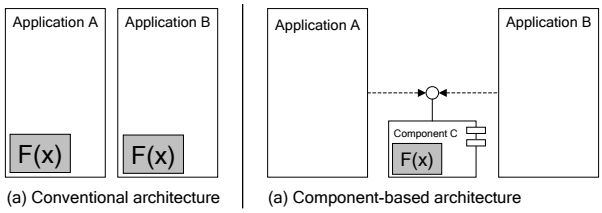

Figure 1: Difference between monolithic and component based software architectures

A couple of concepts in this area are fairly new. Hence, long term experiences, especially in maintaining huge component based software systems in which multiple applications operate, are still missing. Updating such systems still is an unsolved problem but will become more important in the future [1]. Changing the interfaces of new component revisions may cause unforseen effects including system breakdowns or data loss. Components that encapsulate central features and are therefore used in multiple applications create indirect dependencies between otherwise independent system parts (cf. figure 1). Updating such components is a challenging mission if no tools are at hand that help ensure the compatibility of all the possible configurations.

Our approach to help component developers and system integrator to update their systems is twofold: Initially we created a formal model to map the features of modern, object oriented component models that allows us to check, if a system composition is well-balanced, which means that all required interfaces are covered by compatible providers. The model allows the inheritance of interfaces over the boundaries of single components, which often caused the fragile-base-class-problem in update scenarios. The model is implemented in Prolog and embedded into our update-tool **Componentor**.

The second part of our approach rests upon the aforementioned mechanisms and targets at the dynamic reconfiguration of component based software systems in case of an update. Starting from a set of applications and some specified component revisions, the intention is to find the best system composition, regarding compatibility, minimality and newness of the component revisions. Unfortunately this Constraint Satisfaction Problem (CSP) is, like graph-coloring, provable NP-hard, as it can be transferred to the 3-SAT problem. In industry (in particular in machine scheduling) or logistics (routing) these kinds of problems are solved by branching the exponentially growing search-space using different heuristics (minimum remaining values, degree heuristics, least-constraining-value, forward-checking, conflict-directed-backjumping, min-conflicts). Close to our original problem, we implemented a series of heuristics into our prototype and are currently investigating, which of the heuristics achieves the best results.

[1] A. Stuckenholz: Softwarekomponenten und ihre Update-Zyklen - Eine Marktanalyse, Praxis der Information und Kommunikation, 2006, To appear.

Growing Interest-Oriented Self-organizing E-Learner Communities

Fan Yang

Recently, web based learning technology enables many more students to have access to e-learning environments, which provides students and teachers with an unprecedented flexibility and convenience. But this teacher-centered and student-dispersed learning mode bears inherent limitations such as learner passiveness or lack of interaction, which lead to the generation of a lot of lonely e-learners [1].

In order to find an effective way to group learners automatically based on the dynamic learning behaviors and push them personalized learning recommendations,we have proposed a novel personalized approach based on the self-organized reciprocal community (SORC) [2]. The concept "E-Learner Community" referred here is a group of e-learners who share common preferences and have the capability to mutually satisfy each other's requirements in terms of relevant knowledge.

We proposed a two-level community structure linked through group agents which help to find the similar learners with similar interest.

1. Here, each learner agent (LA) operates on behalf of a real learner, which can only belong to a unique group agent (GA). On initialization, each LA will be assigned an initializing group membership. This value is to estimate the strength of how much the learner's interest belonging to the primary interest of its group. Beyond this, the LA also maintains a set of resources, rating vector of each resource.

2. In order to find similar learners, we enable each LA can submit a "Recommend Request" to its group agent, including the title of this resource and his rating value on it. After receiving this request, its group agent will help to find the learners also interested in the resource d in the global environment, first in its local community, then the other communities.

3. Once the matched similar learners are feedback, the following problem is how to decide which learners should be re-grouped together. Thus, we define the award-adjustment and member-exchange rules to update the group membership and community structure. The principle rule of the re-organizing is to move the LA with lower TA to the group managing the other LA with higher TA.

Based on this strategy, we evaluate the performance of the algorithm from the recommendation accuracy and scalability. We give the experiment based on 1500 learners. And we found that with the more and more recommendation requests submitted, there is the increasing accuracy and after 50 requests the accuracy increased to more than 90We also tested the scalability with varied numbers of learners ranging from 1000 to 5000, the experimental results show this parameter increased almost linearly in relation to the number of users, which verify that it is scaled with the increased number of users effectively.

[1] C. Bouras, D. Psaltoulis, C. Psaroudis and T. Tsiatsos. An Educational Community Using Collaborative Virtual Environments. In Proceedings of the First International Conference of Web-based Learning (ICWL 2002), HongKong, China, August 2002.

[2] F.Yang, B. Kraemer, P. Han, R.M. Shen. Journal of Integrated Design and Process Science, v 9, n 2, pages 1-11, 2005.

Ontology Similarity in Semantic Web Services

Xia Wang

When considering the matchmaking of two Semantic Web Services (SWS), one of the key challenges is to analyze how similar their ontologies are. One possibility is to compute a semantic distance between them. This work relies on specifications written in OWL-S (which is a semantic description language for services) to investigate the state-of-the-art of ontologies in semantic web service environments. It presents definitions of ontologies in the OWL-S context, characterizes their specific name features, and further proposes an integrated algorithm to calculate the distance of ontology vocabularies in SWS application domains. This work contributes not only to discovery, composition, and invocation of semantic web services, but also to data mining, web mining, and other related fields.

Examining OWL-S specifications, ontology vocabularies in SWS have special name features, because they are defined by developers sometimes relying on their own experience and preferences. The ontology vocabularies are not the formal form in thesauri like WordNet, but might be associated words with capitalizations or delimiters, with suffices and prefices, variations or misspellings, abbreviations etc.

Differentiating the different cases of ontology vocabularies, three algorithms are combined to measure the similarity of ontologies of SWSs [1]. The fuzzy-weighted associative network is an approach which builds a semantic network to calculate the shortest distance between the nodes denoting ontology terms. This method is effective when there are abundant semantic relationships of ontologies. The information-theoretical approach emphasizes on how much information two ontologies share. It measures the similarity by calculating the commonality and difference of ontologies. These two approaches work very well when the vocabularies are formal words. While, when the ontology vocabularies are associated words, the clustering algorithm will be adopted. The basic idea is, if two terms occur together often, they are similar. For the clustering algorithm, the similarity is measured by computing the conditional probability of their co-occurrence in the semantic description of services.

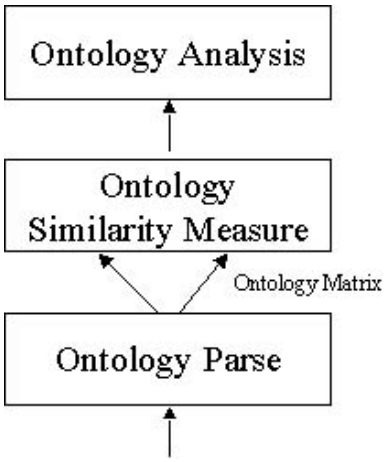

Figure 1: Similarity Measure of Ontologies

Our algorithm combines the above three sources of evidence with different weight values w_i, so that an abstract semantic distance can be calculated as follows:

$$dis = w_1 * Dis_s + w_2 * Dis_i + w_3 * Dis_c, \qquad w_1 + w_2 + w_3 = 1 \tag{1}$$

where Dis_s, Dis_i and Dis_c respectively denote the results of the three approaches above.

Fig. 1 illustrates the architecture of an experiment which consists of three parts. From bottom to top, the first one is the *Ontology Parser*, which reads in OWL-S documents of services, parses them (which includes discarding any tags) to obtain ontology vocabularies, and stores them into the relevant matrix. The second part is the *Ontology Semantic Measure*, which calculates the similarity of ontology vocabularies by applying the above algorithms, respectively. The last one is the *Similarity Analysis*, which is mainly used to evaluate and analyze the results of experimentation.

[1] X.Wang, Computing Semantic Distances Between Ontologies in Semantic Web Service Environment, Technical Report July 2005.

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Creating Models To Understand Programs

Philipp Bouillon

Today's computer programs are tremendously complex. Still, a common task is to further improve and extend those programs and to add new features. Sometimes, a piece of software might already have all the features it requires but the code needs to be adapted so that the software conforms to new regulations. Most of the time many people are involved in the implementation process of the software and usually nobody understands the entire system, so it is imperative to aid the programmers in understanding and extending existing program code.

True, to partly eleviate the problem, design documents exist and they can give all involved programmers an overview of the critical routines of a program. However, those design documents are often out of date and do no longer reflect the current state of the software. Thus it becomes necessary to provide an automatic means to infer needed information directly from a program.

We retrieve information about a program by analyzing the run-time generated method-invocation traces of several program runs. The process is fully automated and provides the programmer not only with a better understanding of the program at hand but with a *model* of the program that is not limited to program understanding but can be applied to redesigning, refactoring, reverse engineering, debugging, and more.

Our approach [1] consists of several steps in order to construct the model of a program:

Retrieve Event Traces. Before we can think about creating a model of some sort, we first have to create a pool of data from which to extract that model. We have decided to dynamically analyze object-oriented programs and extract their *event-traces*. An event-trace is a sequence of method-calls and return statements that are all attributed to a specific *object*—as opposed to the general *class* of that object.

Transform Traces into Graphs. To obtain our graphs, we use different approaches. The first approach that we have taken uses sequences of calls which are extracted from event traces. They are modeled into so called *Sliding Window Graphs* which represent a control-flow like view of the program. We are currently combining this approach with Probabilistic Finite State Automatons (PFSAa) and use machine learning strategies to improve the results. The graphs obtained from all our strategies are then combined, yielding a consistent description of the program.

Interpret the Graphs. In this step, we can finally begin to analyze the obtained data and derive a model from it. To do that, the graphs from various program runs are collected and then compared. Differences between the graphs can be interpreted as a possible bug in the program.

Present the Information. Since Sliding Window Graphs are rather counter intuitive to programmers, we have to present the information gathered by our model in a way that is more informative for the programmer. Currently, we present a list of found irregularities.

First results of our work have shown that we can find probable bugs in a program if a *strange* behavior, for example a reversion of a calling sequence, occurs. We can also generalize our method and apply it to web services in order to analyze the data flow, we can learn the typical user interaction of a web site and we can learn from a project history in order to prevent future bugs.

[1] P. Bouillon: Object Based Dynamic Model Extraction, *Softwaretechnik-Trends Band 25, Heft 2*, 2005.

Information Flow Control Based on Path Conditions in Dependence Graphs

Jens Krinke

Information Flow Control (IFC) is an important technique for discovering security leaks in software. IFC has two main tasks:

- guarantee that confidential data cannot leak to public variables (*confidentiality*);
- guarantee that critical computations cannot be manipulated from outside (*integrity*).

State-of-the-art IFC exploits *program analysis* to assign and propagate security levels to variables and expressions, guaranteeing that any potential security leak is found. This has the huge advantage that it can exploit a long history of research on program analysis, and will discover any security leaks caused by software itself, though this approach may miss information flow through e.g. physical side channels, which are usually handled by separate approaches.

Most contemporary analysis methods are based on non-standard type systems. Security levels are coded as types, and the typing rules catch illegal flow of information. Type systems can handle sequential as well as concurrent programs, and can even be used to discover timing leaks. However, type-based analysis is usually not flow sensitive, context sensitive, nor object sensitive. This leads to imprecision and thus to a high number of false alarms. Fortunately, program analysis has much more to offer than just sophisticated type systems. In particular, the *program dependence graph* (PDG) has become, after lively research in adaptations for real world languages, a standard data structure allowing various kinds of powerful program analyses. We therefore base IFC on a combination of *dependence graphs* and *constraint solving*.

In this work [1], we augment Java PDGs with Denning-Style security level lattices, noninterference and introduce path conditions for Java PDGs. Noninterference was introduced by J. Goguen and J. Meseguer in 1984: Every statement a has a security level $dom(a)$. Noninterference between two security levels means that no statement with security level d may influence a statement of security level e. In our approach, statements resp. nodes in the program dependence graph are marked with *provided* and *required* security levels that specify the security level of outgoing information and the maximal incoming security level. From the specified security levels we compute a *generated* security level and check if the generated security levels do not violate the noninterference criterion.

If a security violation is discovered at a node (resp. statement), we are able to compute path conditions that give precise necessary conditions under which the security violation may occur. Path conditions can (sometimes) be solved for input variables, such solved conditions act as a witness for illegal flow: it will become visible when the program is fed with the witness.

If programs are executed which have not been checked for noninterference and a security violation is observed during runtime, another approach can be used to reveal the path condition for this violation. Our approach [2] uses captured trace data to compute path conditions only for executed statements and to make the path condition more precise by using the captured values of the program's variables.

[1] C. Hammer, J. Krinke, G. Snelting: Information Flow Control for Java Based on Path Conditions in Dependence Graphs. Proc. *IEEE International Symposium on Secure Software Engineering (ISSSE '06)*, Washington D.C., March 2006.

[2] C. Hammer, M. Grimme, J. Krinke: Dynamic Path Conditions in Dependence Graphs. Proc. *ACM SIGPLAN 2006 Workshop on Partial Evaluation and Program Manipulation (PEPM '06)*, Charleston, South Carolina, January 2006.

e-learning and education (eleed)

Jens Krinke, Bernd Krämer

After a long time of research on e-learning, we observe e-learning applications settling in educational institutions at a large scale, in organizations and in corporations all over the world. The mostly IT-literate group of early adopters is now joined by specialists from many different scientific disciplines who want to share their experiences and learn from each other.

The open access journal "e-learning and education (eleed)" aims to provide a forum for researchers and practitioners active in the field of e-learning and become a focal point for the exchange of high quality scientific research results and experience reports addressing all aspects of e-learning theory, practice and technology. In addition, eleed supports co-operation and community building and fosters the evolution of open e-learning standards. The journal strives to maintain an international balance by relying on experts from all corners of the world.

eleed is a peer-reviewed archival online journal with a quarterly publication cycle. Besides peer-reviewed research papers, survey articles, case studies, and best practice reports, each eleed issue will include non-reviewed short contributions. Examples are: project descriptions, book, product and standards reviews, position statements, and discussion threads.

Open access is a key topic of this electronic journal. All articles are published under the Digital Peer Publishing License, which both ensures free distribution and secures the author's rights that no content is modified or reused without citing the names of authors and holders of rights and the bibliographical information used. Additionally, the rights to use in physical form, particularly the rights to distribute the work in printed form or on storage media, are retained by the authors or other rights holders and are not covered by this license. We are in the middle of the ongoing discussion on open access. There are two important reasons: First, open access articles have significantly higher citation impact than non-open access articles. Second, open access is a way out of the libraries' journal budget crisis. Many people are talking about the "golden road" and the "green road" of open access. The green road is basically self-archiving of traditional publications by the authors. The majority of journals allow self-archiving and many authors already "archive" their articles either on their web page or in a dedicated repository. However, the potential readers still have to find these articles. We are on the "golden road" by actively promoting an open access journal. Our journal is free for all and the long term accessibility is ensured; no articles will "vanish" because an author moves or removes his web pages.

The electronic format of the journal enables the use of non-traditional add-on materials like multimedia animations or simulations and therefore takes the specific possibilities of e-learning into account. Though published like a traditional journal to ensure citability, eleed tries to achieve timely availability by a fast review process and pre-issue publication.

This journal is embedded in the Open Access Initiative "Digital Peer Publishing NRW". In this initiative, 10 open access journals are published within an infrastructure that has been specifically developed by the hbz (Hochschulbibliothekszentrum des Landes Nordrhein-Westfalen).

[1] J. Krinke, M. Roos: Erfahrungen mit dem Open-Access-Journal "eleed (e-learning and education)". Proc. *Knowledge eXtended*, Jülich, Germany, pp. 123-134, November 2005

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The Method of Geometry based Simulation (MGbS) for Automotive DC-Motors

Linh-Thao Stubenbord

I. Introduction

During the development of electric vehicle motors, some very interesting relationships between the motor geometry and the EMC behaviour are observed. Inspired from these relationships a new method is developed. The Method of Geometry Based Simulation (MGbS) for Automotive DC-Motors enables the simulation of the behaviour of DC- motors dependent on the geometric parameters.
It does not only help to analyse many complex relationships between EMC and the geometric parameters of motors but also to improve their EMC quality at an early stage of the design process. Sophisticated und costly testing with prototypes can be replaced by numerical computing.

II. Applications

The main applications of the MGbS in design and development of vehicle DC-Motors are:

- Identification of weakness and interference path: the EMC-Problems can be solved by analysing the cause and the spreading of the interference. MGbS provides the possibility to detect weakness and to investigate the extension path of the problems with the help of visualisation.
- Weighting of construction characteristics: Many construction characteristics of DC-Motors, such as the case length of the motor, are EMC important. MGbS makes it possible, not only to identify but also to quantify how important the effect of different construction characteristic can be.
- Comparison of different design variants and EMC measures. By changing the construction characteristics of the motors, it´s possible to reduce the interference intensity. But it is often difficult to select the best measure out of a row of possibilities und to predict their shielding efficiency. MGbS provides the possibility to evaluate different shielding conceptions and to decide for the best one.
- Optimisation of motor construction. In the design and development process predictions of an improved or optimised geometry of critical components are very helpful. MGbS enables the construction of EMC optimised motors.

III. Description of the Method

The MGbS for DC-motors. requires first of all an appropriate model of the DC-motor. With the help of field solvers the electro magnetic field distribution of the model can be reproduced. The method, that can simulate the interferences behaviour of small DC-motors, combines also skilful strategies and optimisation methods to solve efficiently EMC-problems. The method handles the problem in many steps.

IV. Example Applications

This method is also illustrated by many practical examples. In the first example it is shown, how to design the route of conductors of a wiper motor. In the second example the electromagnetic effects of the case length of a blower motor [1] are identified and explained. In the third example different design variants to reduce the interference intensity of a DC-Motor are compared. In the fourth example the best position and width of a retaining clip of a blower motor are computed.

References:

[1] *F. Meier, A. Nägele, A.J. Schwab,* Parameteruntersuchung der leitungsgeführten Störemission kleiner Gleichstrom-Kollektormotoren im Frequenzbereich 0,1 bis 100Mhz, S. 775-782 EMV´98, Berlin, VDE-Verlag, 1998, S. 487-493EMV´00, Berlin, VDE-Verlag, 2000.

Three-Level Converter as Active Power Filter

A. Vodyakho, D. Hackstein

The active compensation of harmonic currents, using pulsed current rectifiers with IGBT (Insulated Gate Bipolar Transistor) technology, enables to compensate both – harmonic power and fundamental reactive power. Using the APF the compensation runs dynamically. APF current source converts desired value to output current. A capacitor bank gives DC voltage source. IGBTs switching DC voltage to network with needed polarity.

In recent years, there has been an increasing interest in using multilevel inverters for high power energy conversion, specially for drivers and reactive power compensation. Multilevel inverters can be connected to high voltage source without a coupling transformer. Three different topologies have been proposed for multilevel inverters[1]: diode-clamped (neutral-clamped) ; capacitor-clamped (flying capacitors); and cascaded multicell with separate dc sources.

Through manipulation of the cascade inverter, with diodes blocking the sources, the diode-clamped multilevel inverter was then derived. The use of neutral-point-clamped (NPC) inverters allows equal voltage shearing of the series connected devices in each phase. However, the neutral point potential deviates, resulting in an excess voltage stress to either the upper or lower set of devices.

Basically, multilevel inverters have been developed for applications in high voltage ac motor drives and static var compensation. For these types of applications, the output voltage of the multilevel inverter must be able to generate an almost sinusoidal output current. In order to generate a near sinusoidal output current, the output voltage should not contain low frequency harmonic components. The generation of the inverter output voltage is perfomed by using well known PWM or vector control techniques which will calculate the gating signals.

For active power filter applications the three level NPC inverter output voltage must be able to generate an output current that follows the respective reference current which contain the harmonic and reactive component required by the load. The power circuit topology is shown in Fig. 1 [1].

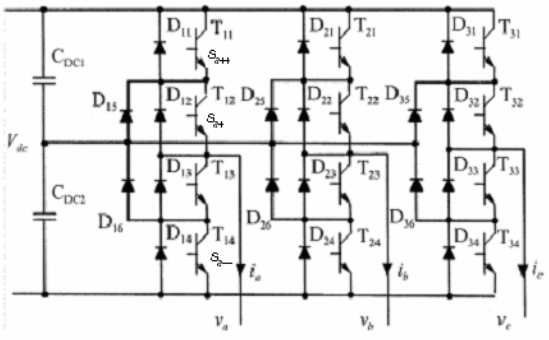


Fig. 1 *Three-level NPC Converter*

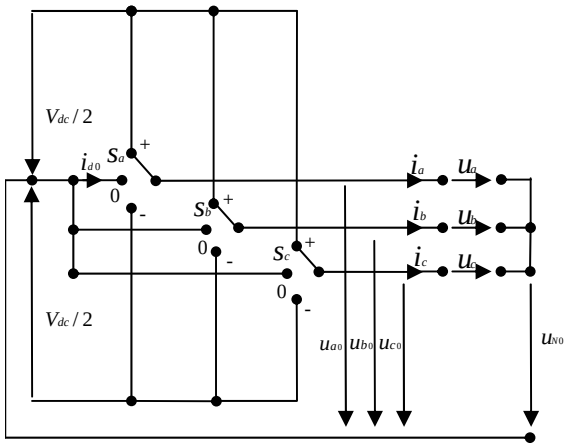


Fig. 2 *Switching network of a Three-level NPC Converter*

References: *F. Jenni, D.Wüest, Steuerverfahren für selbstgeführte Stromrichter. ETH Zürich 1995*

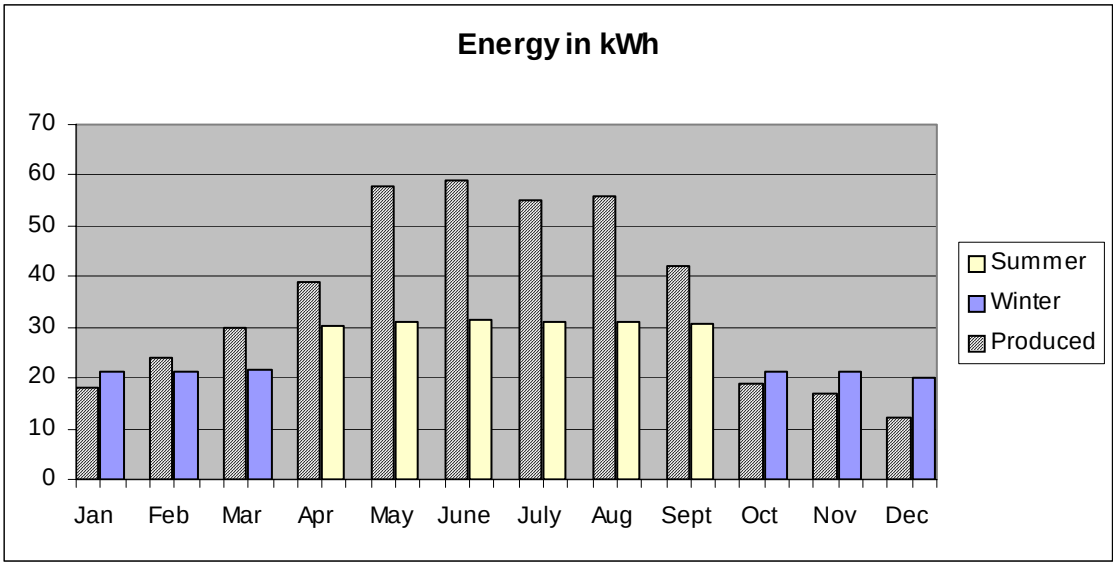
Bus stop with photovoltaic supply at FernUniversität Hagen

Wolfgang Köhler

The bus stop in the neighbourhood of FernUniversität Hagen is used as a showcase project of electrical power engineering with regard to the renewable energies.

After an operating time of 15 years the defect stationary OPZ solar batteries were replaced by dry fit solar gel batteries. The electronics assembly for charging and discharging as well as the controller for the advertisement display case were redeveloped and renewed. The consumption of the display and the supply with solar power are measured now, saved and shown on a display screen.

The diagram below shows the produced energy in kWh per year and the consumption during winter and summer.



The bus stop at the FernUniversität Hagen

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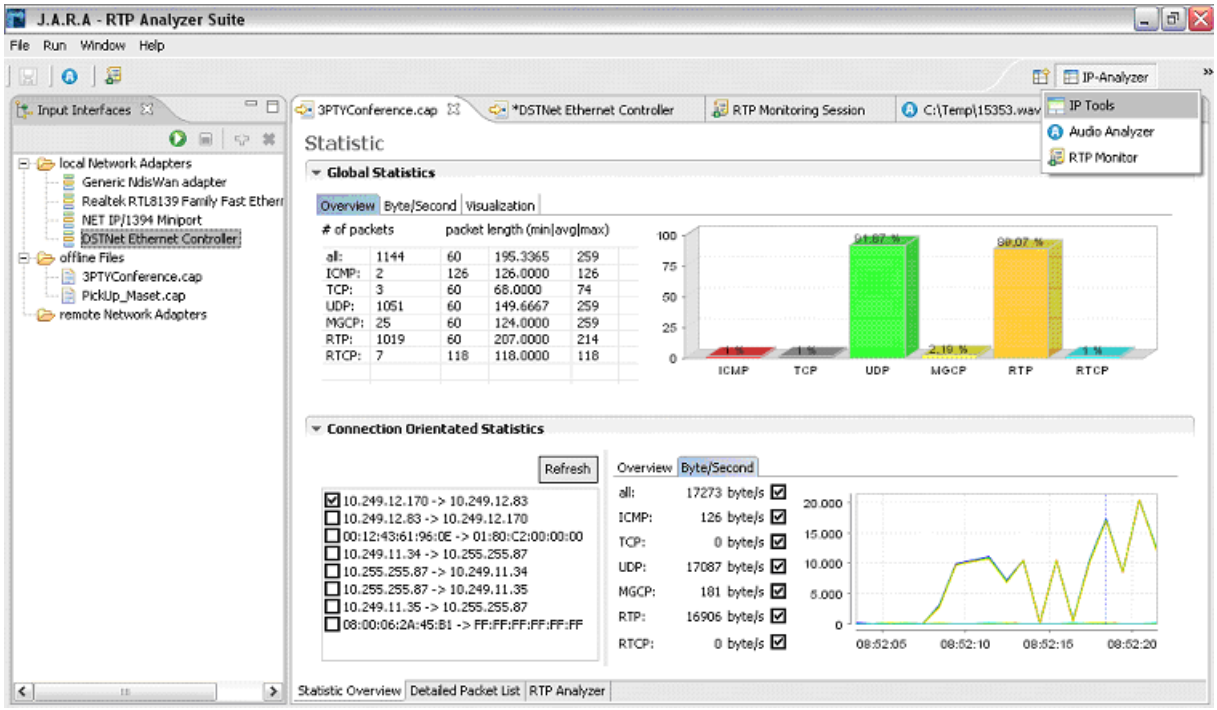
Measurement Toolkit for QoS - Supervision of RTP Streams - RTP Monitor

Michael Kupfner, Fritz Heinrichmeyer, Horst Wupper

Voice over IP (VoIP) market is expanding rapidly. Unfortunately, the Internet Protocol was not designed to guarantee reliable, real-time transmission of speech packets. Therefore, a minimum requirement regarding bandwidth, packet loss, packet delay and jitter exists for every VoIP provider that wants to offer VoIP calls in reasonable quality.

This diploma thesis, supported by Siemens AG, covers creation of an eclipse based software toolkit for monitoring bandwidth usage and performance evaluation of RTP and RTCP streams [1], [2].

Acting as an RTP Monitor, all RTP and RTCP packets related to a RTP session are evaluated. The amounts of duplicated, miss-ordered, wrongly coded or lost packets are displayed. Rendering of audio payload is supported as well as transcoding to different audio formats. Analysis of audio signal spectra is integrated as well.



RTP Analyzer.

References:

[1] Michael Kupfner, Meßsystem zur Feststellung von QoS-Metriken für RTP-Streams –RTP Monitor–. Diploma thesis at chair of electronics at FernUniversität in Hagen, 2006.

[2] IETF, RFC 1889, RTP: A Transport Protocol for Real-Time Applications, http://www.ietf.org

[3] Michael Kupfner. Ethernetgesteuerte Teilnehmeremulation zum Anschluß an SLMA-Baugruppen. Diploma thesis at chair of electronics at FernUniversität in Hagen, 2004.

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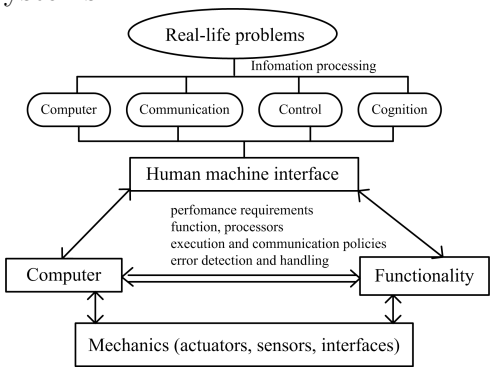
Research interests

Dependable platforms for real time computing
Safety related embedded control systems emphasising licensable software
Engineering of distributed and embedded control systems based on UML
Malware protection by means of hardware
Semantic web

Real-Time Computing for Control

W.A. Halang et al.

A new approach in control engineering, viz., Information Processing for Action, is presented in [1], in which control, computers, communication and cognition play equal rôles in addressing real-life problems from very small-scale devices to very large-scale industrial processes and non-technical applications. Thus, the paradigm "Computers for Control" is shifting towards the paradigm "Computers, Communication and Cognition for Control" providing an integrated perspective on the rôle computers play in control systems and control plays in computer systems. This change is mainly due to new developments in computers and knowledge management, and the rapidly emerging field of telecommunications providing a number of possible applications in control. Control engineers need to master computer and software technologies to be able to build the systems of the future, and software engineers need to use control concepts to master the ever-increasing complexity of computing systems.



Essential design issues for computer control systems

Software-intensive control systems are becoming progressively more complex, prevalent in numerous industrial sectors, and decisive for human safety and for reliability. As there is an accelerated growth of demands for functionality and dependability of such systems, our intellectual and engineering abilities are being challenged to come up with practical solutions to the problems faced in the design and development of complex real-time and safety-related control systems. Even though software testing is an essential part of manufacturing embedded systems, and significant research efforts have been devoted to it, the current state of the practice in system and software verification and validation (V&V) leaves much to be desired. In many industries, V&V is not receiving the attention deserved, and other important activities such as testing functional and non-functional requirements, modeling large software systems, conformance, acceptance and qualification testing, or measuring the effectiveness of different V&V approaches have not yet been incorporated into the V&V processes employed. Therefore, in [2], state-of-the-art methods to assess quality and reliability of software-based systems with the help of validation, verification and test across various domains were compiled.

References:

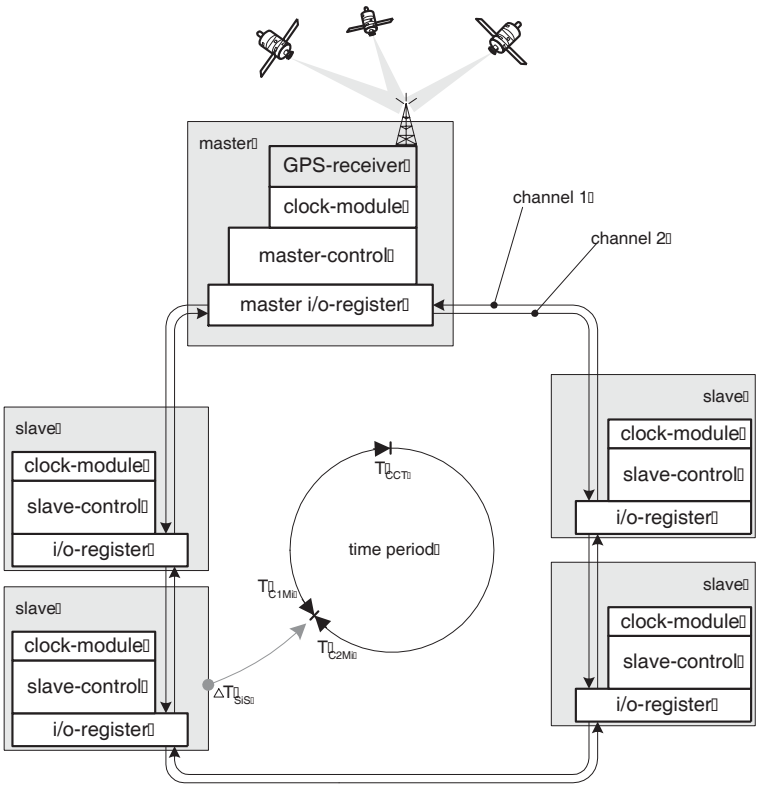
[1] W.A. Halang, R. Babuska, H. Roth and R. Sanz: Information and Communication Technology Embraces Control. Proc. *16th IFAC World Congress — Selected Plenaries, Semi-Plenaries, Milestones and Surveys*, P. Horacek, M. Simandl and P. Zitek (Eds.), pp. 132 – 139, Prague, 2005

[2] M. Colnarič, W.A. Halang and M. Węgrzyn: *Real-Time Programming 2004*. Oxford: Elsevier Science 2005, ISBN 0-08-044582-9

Clock Synchronisation in Nodes on a Ring Bus

T. Erdner, W.A. Halang, K.C. Chan and J.K. Ng

As wired interconnections of stationary distributed (sub-) systems often dual ring buses are employed, as they provide for fault tolerance by redundancy and for predictable data transmission delays. On such a dual ring bus every telegram is transmitted in parallel on both data channels (channel 1 and channel 2), but in opposite directions, as shown in the figure. The transmission delay of a telegram sent from the bus master to a slave depends on only two configuration constants, viz., one holding for the entire bus (T_{CCT}), and the other one being a function of the slave's position on it (ΔT_{SiS}).



Clock synchronisation in nodes on a dual ring bus

Given these constants, each slave can synchronise [1] its local clock with the clock of the master node every time it receives a telegram, provided the latter contains the information when it was sent. Temperature effects can easily be compensated for by measuring the difference between the arrival times of a telegram's versions travelling on both rings. Hence, for a distributed system interconnected by a fieldbus, only one receiver for official time signals as broadcast by, for instance, the Global Positioning System (GPS) is required in its master unit to provide for accurate timing synchronous with the official and legal Universal Time Co-ordinated (UTC).

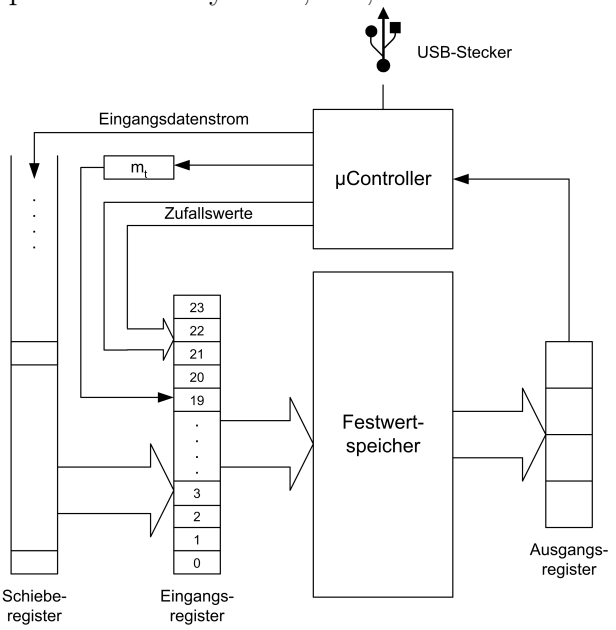
Reference:

[1] Th. Erdner, W.A. Halang, K.-Y. Ng and K.-C. Chan: Synchronisation der lokalen Uhren an ringförmigen Übertragungsmedien angeschlossener Einheiten. German patent No. 10253534, 2005

Security of Computers and Data Transmission

W.A. Halang and R. Fitz

More and more automation applications are implemented on the basis of cheap PCs as control computers and the Windows operating systems. As such computers are swamped with attacks, there is a considerable risk also for industrial computing systems to be infected by malware and, thus, to become unsafe. This is exacerbated since almost any enterprise is present in the Internet, since firewalls are unable to protect intranets against external attacks, and as antivirus software becomes obsolete almost momentarily and can detect known malware, only. Hence, the security problem must be solved in a fundamentally different way, viz., by appropriate architectures. To this end, constructive security measures were devised [1], which intrinsically thwart the operation principles of malevolent programs. It is possible to build systems which are immune against intruders and espionage. In addition, separation and structuring considerably facilitates the maintainability of computer control systems, too, and even increases their performance.



Circuitry for most general form of encryption

In cryptography, the data elements to be transmitted are always subjected to encryption as unaltered units. Also, Shannon's information theoretical model of encryption systems is based on this restrictive fundamental assumption. Hence, information such as the boundaries between the data elements and their number is easily observable in ciphertext, i.e., in general there is a one-to-one correspondence between plaintext and cipertext symbols – a feature facilitating code-breaking. Therefore, in [2], for encryption the most general form of replacing a bit pattern by another one is introduced. It allows to blur the boundaries between plaintext symbols, and enables several, randomly selected encryptions of a single bit pattern having more bit positions in the ciphertext than in the plaintext.

References:

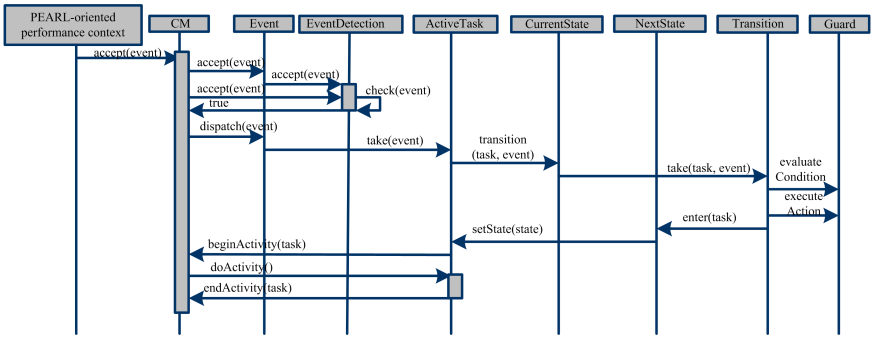
[1] W.A. Halang and R. Fitz: Security of Control Computers. In *Real-Time Programming 2004*, M. Colnarič, W.A. Halang and M. Węgrzyn (Eds.), pp. 79 – 84, Oxford: Elsevier Science 2005

[2] W.A. Halang: Verschlüsselung binärer Daten. German patent registration no. 10 2005 006 713.1, 2005

Modeling Safety-Critical Embedded Real-Time Control Systems with UML

S. Lu, W.A. Halang and N. Kececi

In developing computer control systems, the assurance of safety – during the entire life-cycle – becomes more and more important. Safety must be considered right from the conceptual phase. To this end, it is state of the art to identify specific safety requirements, to perform hazard and risk analyses, and to certify systems as well as dependability structures against safety standards before being put into operation. Aiming to design robust systems with fail-safe behaviour free of implementation faults, it is envisaged to provide specifications of safety properties within the framework of profiles for the Unified Modeling Language (UML), which are oriented at the prevailing safety standards and which can be incorporated into models of safety-related embedded real-time control systems.



Sequence chart for activity scenario

To achieve this goal, it is explored [1] to extend UML by defining a safety mechanism collected in a profile based on safety standards for the development of safety-critical systems. A set of UML stereotypes is introduced providing the functionality of safe subsets needed to design safety architectures corresponding to subsets of the real-time programming language PEARL and to Function Block Diagrams according to IEC 61131-3. These constructs are ordered in nested sets to fulfill the respective requirements of the four Safety Integrity Levels of IEC 61508-1. Using UML syntax, these extensions can be integrated into the standard UML framework, since they are based on the UML metamodel. To enable the specification of safety-related software, a fault-tolerance framework to be used in the process of designing and developing computerised control systems was devised [2], which is based on well-proven fault-tolerance techniques and FT-CORBA. The framework, the mechanism contained, and system architectures making use of it are all described employing extensions of UML. Use of the framework enables reasoning about system dependability already at an early stage of system development, and to customise fault-tolerance strategies according to application characteristies.

References:

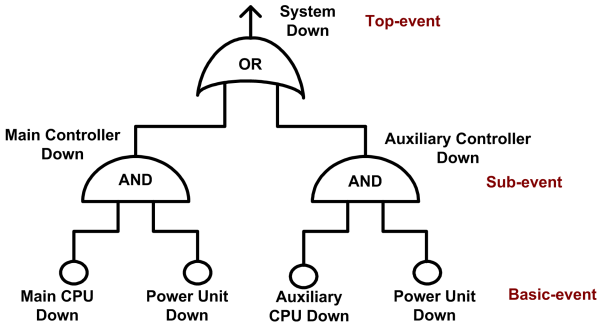
[1] S. Lu and N. Kececi: A UML Profile for Modeling Safety-Critical Embedded Real-Time Control Systems. In *Real-Time Programming 2004*, M. Colnarič, W.A. Halang and M. Węgrzyn (Eds.), pp. 115 – 120, Oxford: Elsevier Science 2005

[2] S. Lu and W.A. Halang: Comprehensive Modeling of Computer Control Systems' Functionality and Fault-Tolerance in UML. Proc. *16th IFAC World Congress* P. Horacek, M. Simandl and P. Zitek (Eds.), Prague, 2005

Component-based Hazard Analysis in the Design of Safety-Critical Systems

S. Lu, R. Gumzej, W.A. Halang, H.-W. Schmidt and J. Zalewski

Fault Tree Analyses (FTA) are embedded into component models described with the Unified Modeling Language (UML) [2]. Such models are constructed by employing UML's inherent extension mechanisms in conjunction with component-based software engineering techniques. Taking an application's safety requirements into consideration, the elements of FTA are defined as component attributes, and assigned to a UML component model, which is collected in a UML profile for safety analyses and architectural design. Based on the thus enhanced architecture specification of the UML component model, it becomes possible to handle hazard analyses and to model safety mechanisms at the same time.



FaultTree Elements	UML Stereotype
BasicEvent	<<BEvent>>
UndevelopedEvent	<<UEvent>>
IntermediateEvent	<<IEvent>>
NormalEvent	<<NEvent>>
ConditioningEvent	<<CEvent>>
AndGate	<<AndGate>>
ORGate	<<ORGate>>
InhibitGate	<<InhibitGate>>
ExclusiveORGate	<<EORGate>>
PriorityANDGate	<<PANDGate>>
VotingORGage	<<VORGate>>
Edge	<<Edge>>

Fault tree stereotypes

In [1], an approach to use UML for developing safety-critical systems is presented. Its main characteristic is to perform safety analysis on a UML system model, in the course of which safety requirements can be derived for classes in the system. These requirements can be expressed in the Object Constraint Language (OCL) in form of safety contracts. This enables to reason about the safety of individual elements of the UML model and, thus, facilitates to safely change a UML-based design, as well as to maintain and re-use classes or components in the system. The UML model is described by defining a set of stereotypes, viz., Component, Connector, Port and Role, Interface and Contract. Component is responsible for the functional aspects, while Connector is in charge of the control and communication aspects of a system. A set of Ports is assigned to Component, and Roles are assigned to Connector. These ports and roles are the interfaces of components and connectors, and obey exactly one protocol specifying the order of incoming and outgoing messages. A contract is made up of pre- and post-conditions, which is defined as a class used to specify a components's operation constraints. It can be assigned to a port, connector, or component to express safety requirements.

References:

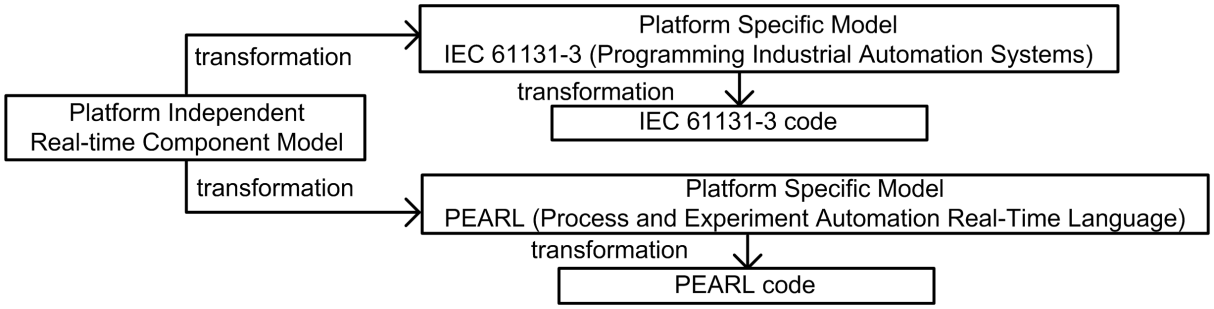
[1] S. Lu, W.A. Halang, H.-W. Schmidt and R. Gumzej: A Component-based Approach to Specify Hazards in the Design of Safety-Critical Systems. Proc. *3rd IEEE Intl. Conf. on Industrial Informatics*, Perth, 2005, ISBN 0-7803-9095-4

[2] S. Lu, W.A. Halang and J. Zalewski: Component-based HazOp and Fault Tree Analysis in Developing Embedded Real-Time Systems with UML. *WSEAS Transactions on Computers* 12, 4, 1852 –1857, 2005, ISSN 1109-2750

Component Architectures for Embedded Real-Time Systems

S. Lu, W.A. Halang and L. Zhang

A novel method to specify component-based software architectures for embedded real-time systems is introduced in [1]. Component models are specified taking the Model Driven Architecture (MDA) approach, and employing notations in the Unified Modeling Language (UML). The method is based on a conceptual framework architecture, in which platform-independent component models are built. Taking specific platform features into regard, then specific component models result from transformations mapping the platform-independent component model to formulations in terms of tasks of the Process and Experiment Automation Real-Time Language (PEARL) or of function blocks according to IEC 61131-3 or IEC 61499.



PIM to PSM transfomations

In [2], component-based UML profiles are built for the development of embedded systems. To specify the specific characteristics of embedded systems, both the Model Driven Architecture approach and component-based modeling are employed. The component paradigm allows to clarify system structures with respect to functionality, while the model driven paradigm provides an efficient way to describe an application with enough abstraction to enable its mapping onto various execution platforms. Component-based UML models are designed as Platform Independent Models (PIM), and translated to Platform Specific Models (PSM) for target-platform implementation, which deal with functional and non-functional properties. Both PIMs and PSMs are collected in UML profiles which can be used as application frameworks for developing embedded real-time systems.

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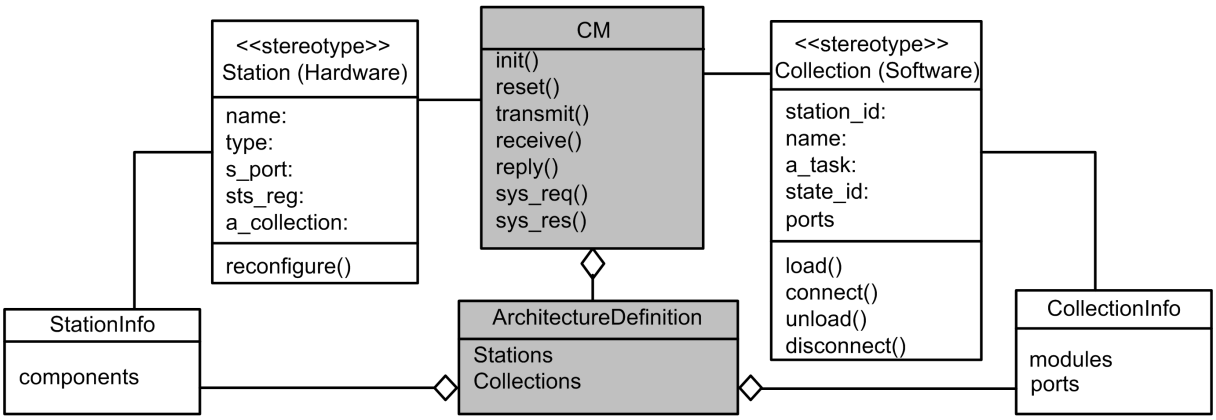
Configuration Management in Embedded Distributed Systems

S. Lu, R. Gumzej and W.A. Halang

Dynamic re-configuration in distributed real-time systems and applications is considered in [1]. In particular, a novel approach to interpret the software and hardware architecture specifications for configuration (re-) parameterisation is indicated. Active and passive objects of the software architecture are identified, where active objects communicate among each other and manage the passive objects and their co-operation. An active "super" object, called Configuration Manager, is foreseen for starting the initial software configuration on its native processing node, any subsequent changes in the software configuration, as well as inter-node co-operation.



Software and hardware architecture managed by the Configuration Manager (CM)

In [2], an idea on how to interpret the software and hardware architecture specifications to parameterise (re-) configurations is indicated. Configuration issues are addressed on three levels of architectural modeling, viz., (1) hardware architecture, (2) software architecture, and (3) software to hardware mapping. They form a basis for the parameterisation of a Configuration Manager (CM), and are described in terms of a Model Driven Architecture (MDA) as a platform-independent model (PIM) profile. In addition, it is indicated what one should consider when constructing a platform-specific model (PSM). The MDA approach turns out to be favourable in this case, since we aim to define a PIM model of the configuration manager, which can then be parameterised to form its PSM model, from which a platform model can be built in a straightforward manner.

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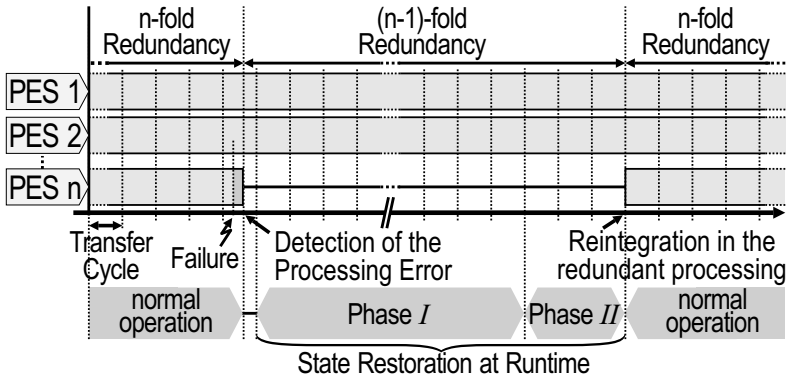
A Real-Time PES Supporting State Restoration at Runtime after Transient Hardware-Faults

M. Skambraks and W.A. Halang

Controlling safety-critical real-time applications that cannot immediately be transferred to a safe state requires highly reliable Programmable Electronic Systems (PESs). This demand for fault-tolerance is usually satisfied by applying redundant processing structures inside each PES and, additionally, configuring multiple PESs redundantly. Instead of minimising the failure probability of single PESs, it is also desirable to provide a redundant configuration of PESs with the capability to re-start single units at runtime. This requires copying a PES's internal state at runtime, since a re-started unit must equalise its internal state with that of its redundant counterparts before the redundant processing can be rejoined. As a result, redundancy attrition due to transient faults is prevented, since failed channels can be brought back on line. The PES concept proposed in [1,2,3], which bases on task-oriented real-time execution in discrete *Execution Cycles*, features this capability of '*State Restoration at Runtime*'. Strict separation of task-administration and -execution enables to distinguish between program-induced and event-induced state changes, and implementing the task administration as digital logic circuit allows for special custom-built opportunities to access the task-administration data.



State restoration process

The transfer policy 'oldest data first' enables to completely transfer the task-administration data by copying a fixed number of oldest data values each cycle. As a result, the maximum amount of task-administration data changes within a cycle does not need to be restricted to a number that enables transfer of the associated state changes within each cycle. Since the transfer policy avoids repeated transfer of often modified data to a large extent, it reduces the required transfer bandwidth – or results in a higher computational performance for a fixed bandwidth.

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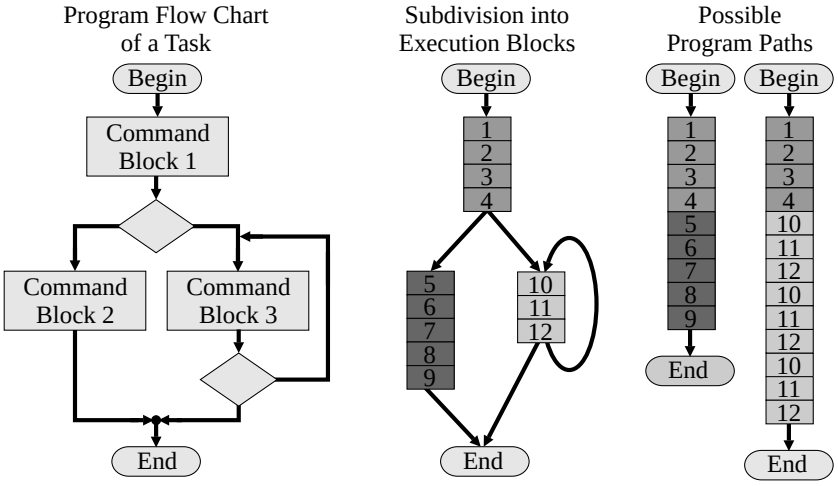
Task-Oriented Real-Time Execution without Asynchronous Interrupts

M. Skambraks

Depending on their operating policies, the PESs currently employed in safety-critical applications can be categorised [1] into *periodically operating* and *task-oriented* ones. The first category, following the approach of *synchronous programming*, operates in a cyclic fashion, and always processes program code completely within a cycle. This strictly cyclic operation allows condition-controlled branching merely on a restricted scale, and limits the field of application to simple control tasks. Nevertheless, architecture and time behaviour are of remarkably low complexity, rendering these systems particularly suitable for applications of highest safety criticality. The second category uses interrupts to control software execution. One one hand, this allows program flows to be arbitrarily controlled by the processes, but on the other, the need arises to prove feasibility. Thus, although asynchronous, task-based programming is more problem-oriented than synchronous programming, this PES category causes much higher effort for safety-licensing.



Dividing program code into Execution Blocks

Motivated by the objective to combine the advantages of synchronous and asynchronous programming, a PES concept has been devised [2], which supports task-oriented real-time execution, but avoids the use of asynchronous interrupts. The application software is organised in tasks but, contrary to conventional task-oriented systems, tasks are subdivided into a number of blocks, which are executed in discrete intervals of constant duration. This execution concept renders special synchronisation mechanisms such as semaphores superfluous, since any task has non-interruptable exclusive access to the processor during an execution interval. As a result, temporal behaviour as well as hardware structure are simiplified, and a higher conformity with IEC 61508 for systems of highest safety criticality (SIL 3/SIL 4) is obtained.

References:

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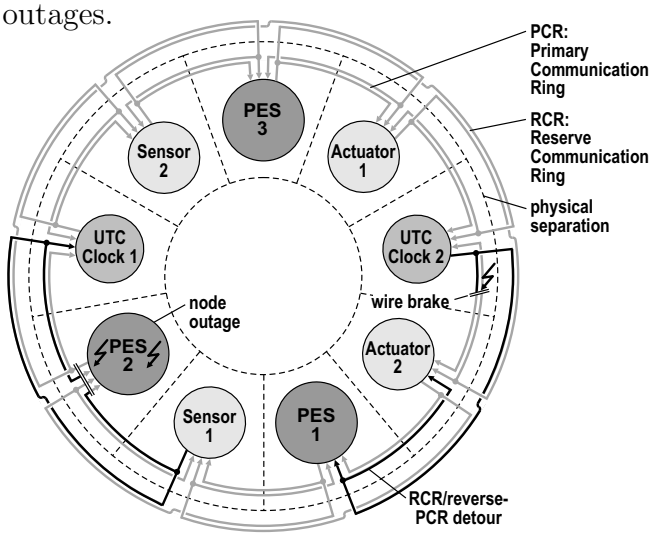
A Fieldbus for Safety-Related Real-Time Operation Supporting Forward Recovery from Redundant Nodes

M. Skambraks, W.A. Halang and P. Neumann

A novel fieldbus concept was devised [1,2,3] for a new safety-related real-time PES, which features task-oriented real-time execution even though it operates in discrete cycles. The fieldbus serves both data exchange with process peripherals and between multiple redundant processing nodes. Similar to the fieldbus 'Interbus', all system nodes, i. e., the redundant PES instances as well as sensors and actuators, are connected to a ring, and data are transferred from node to node as in a shift-register. The transfer is organised in cycles that match the execution cycles of the dedicated PES architecture. A special *multi-ring technique* guarantees uninterrupted operation in case of physical failures like wire breaks or node outages.



Connection scheme with three redundant PESs

The fieldbus fulfills real-time demands and supports state restoration of error-affected or replaced processing nodes at runtime. Its tight integration into the safety-related PES architecture features this form of forward recovery without the drawback of inadequately long system response times. The multi-ring connection scheme combines high, scalable reliability and low wiring expenses with an especially simple structure. Communication is performed in discrete intervals and in synchrony with the cyclically organised application processing, leading to a simple and easy-to-model temporal behaviour of the entire system. This eases verification and reduces the cost for safety licensing.

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[2] M. Skambraks: Neuaufsetzen im laufenden Betrieb nach Fehlereintritt in redundanten Echtzeitsystemen. In *Echtzeitaspekte bei der Koordinierung Autonomer Systeme*, P. Holleczek and B. Vogel-Heuser (Eds.), pp. 67 – 76, Reihe Informatik aktuell, Berlin-Heidelberg-New York: Springer-Verlag 2004, ISBN 3-540-29594-1, ISSN 1431-472-X

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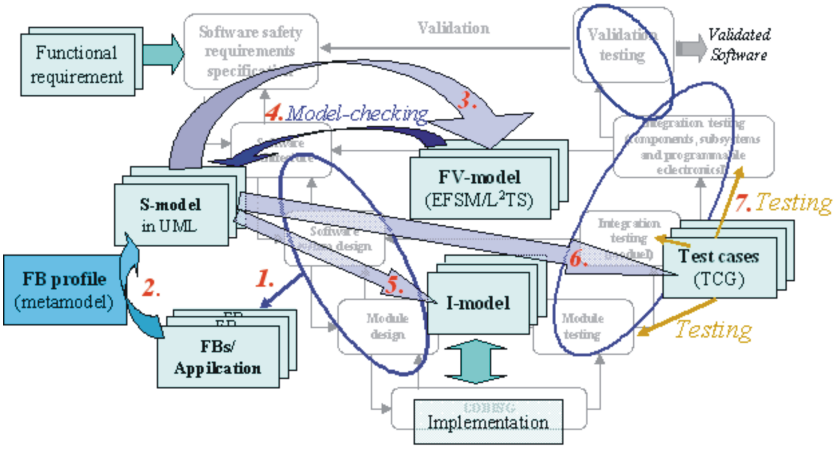
Function Block Paradigm for Safety-related Applications

W. Zhang, Chr. Diedrich and W.A. Halang

According to the principle *Simplicity* ⇒ *(easy) Predictability* ⇒ *Dependability* the function block paradigm is a good candidate to design safety-related applications. Owing to their inherent simplicity, FB-based applications can easily be understood by all project members reducing design errors. Complexity-handling is considered to be another advantage as complexity complicates verification and validation. Compared with object-orientation and component-based software engineering [1], however, the current FB paradigm has shortcomings w.r.t. formal specification, proper process management, and effective tool support. Therefore, it was improved by using UML and the V-model towards providing strict design guidelines to realise the safety life-cycle recommended in IEC 61508.



FB paradigm in the V-model

In the framework of the V-model life-cycle, an automation application is first designed in terms of FBs and, then, specified with UML notations, under the FB profile being the collection of the FB metamodel [2], forming the Specification model (S-model). The third step refers to formalising the S-model by certain formal languages. With the Formal Verification model (FV-model) attained, model-checking is carried out. If this ends successfully, the S-model is regarded to be free of errors. Then, an Implementation model (I-model) is derived for the S-model, and the application's animation or implementation is built. In addition, test cases are generated on the basis of the S-model's analysis, as labelled "6" in the figure. Finally, the implementation or animation is tested by applying test cases selected according to a novel method [3]. This process is usually iterative, with the results of model-checking and testing being fed back into the design stage.

References:

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Junior professorship of

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Research interests

Embedded systems
Applications of chaos control and synchronisation to information and communication technology
Chaos based cryptography

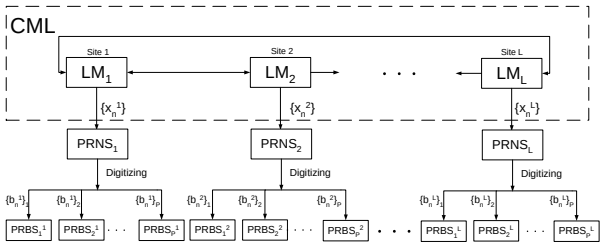
Pseudo-Random Bit Generators Based on Spatiotemporal Chaos

P. Li, Z. Li, W.A. Halang and G. Chen

Chaotic systems are extensively applied in cryptography, such as in designing pseudo-random-bit generators (PRBGs). So far, many chaos-based PRBGs were proposed, among which spatiotemporal chaotic systems have prominent merits when high encryption speed is required. This is due to some inherent features of spatiotemporal chaos, viz., long period orbits, high complexity of system dynamics yielding random orbits, and multiple sites in spatiotemporal chaotic systems, which can be used to generate unrelated pseudo-random-bit sequences (PRBSs) simultaneously. In [1], a multiple-output PRBG based on a spatiotemporal chaotic system is proposed. A nearest-neighbour coupled map lattice (CML) consisting of logistic maps is used as a spatiotemporal chaotic system:

$$x_{n+1,i} = (1-\epsilon)f(x_{n,i}) + \frac{\epsilon}{2}[f(x_{n,i+1}) + f(x_{n,i-1})],$$

where $n = 1, 2, ...$ is the time index, $i = 1, 2, ..., L$ is the lattice site index with a periodic boundary condition, f is a local chaotic map in the interval I, and $\epsilon \in [0, 1]$ is a coupling constant. Here, the logistic map, i.e., $f(x) = rx(1-x)(r \in (0, 4])$ is taken as the local map. The construction of the CML-based PRBG is shown on the left, where the output of the CML is digitised to generate multiple PRBSs in the way as shown on the right:



Construction of CML-based PRBG

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = 0. \begin{bmatrix} b_1^1 \\ b_2^1 \\ \vdots \\ b_n^1 \end{bmatrix}, \begin{bmatrix} b_1^2 \\ b_2^2 \\ \vdots \\ b_n^2 \end{bmatrix}, \cdots \begin{bmatrix} b_1^P \\ b_2^P \\ \vdots \\ b_n^P \end{bmatrix}$$

Digitisation method

Thus, $P \times L$ PRBSs can be generated simultaneously from the CML with L sites. By analysing the largest Lyapunov exponent and the ergodicity of the CML, one can determine the ranges of the parameters of the CML to obtain good cryptographic properties of the PRBG. Moreover, numerical investigation indicates [2] that the PRBS is almost balanced, that its linear complexity is about $N/2$, that its auto-correlation is δ-like, and that its cross-correlation PRBS is close to zero, which indicates that the PRBG has very satisfactory cryptographic properties and high efficiency.

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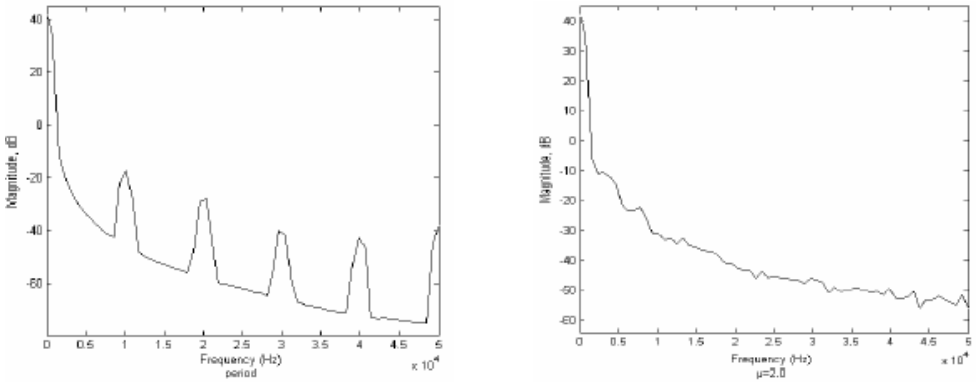
Controlling DC-DC Converters with Chaos-based PWM

H. Li, Z. Li, W.A. Halang and B. Zhang

It is known that some singular or abnormal phenomena often occur in DC-DC converters, such as unexpected collapse of the operating mode, strange electromagnetic interference (EMI), unstable operation and malfunction after relatively long running, perhaps due to system failure or external random disturbance. This greatly limits the application of DC-DC converters. It is also known that due to the cluster harmonics around the multiples of carrier frequency in the output waves of the conventional pulse width modulation (PWM), it is difficult to control the EMI.



Spectra comparison between traditional PWM and CPWM control

This work [1,2,3,4,5] attempts to solve the problems using chaos theory and chaos control methodologies. A chaos-based pulse width modulation (CPWM) is proposed to distribute the harmonics of the DC-DC converters continuously and evenly over a wide frequency range. Consequently, the electromagnetic interference can be controlled and reduced, and the electromagnetic compatibility (EMC) can be improved. The figure above shows the spectra of DC-DC converters controlled by traditional PWM and by CPWM with the logistic map, $x_{n+1} = 1 - \mu {x_n}^2 \quad (\mu = 2)$.

References:

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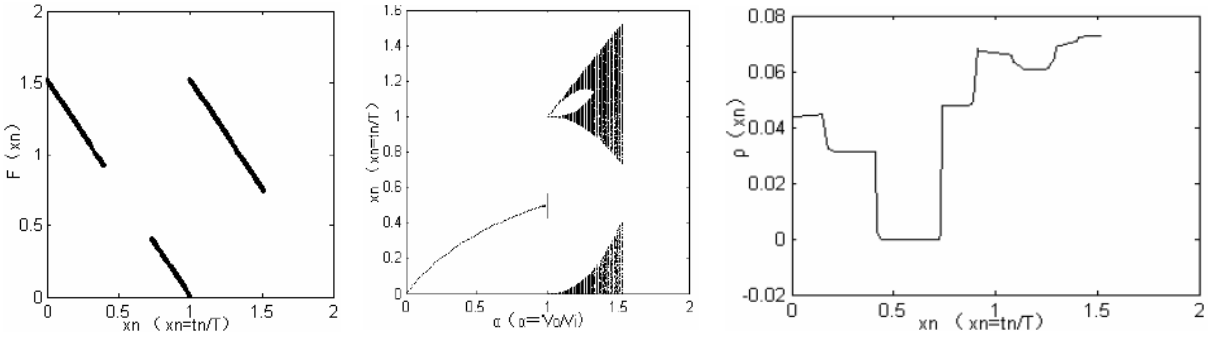
Invariant Probability Density of Chaotic DC-DC Converters

H. Li and B. Zhang

It is well known that DC-DC converters are inherently nonlinear systems, thus, they can exhibit exotic nonlinear phenomena, like bifurcation and chaos, as their parameters are varied. Therefore, the operating state of such a converter is unpredictable when it operates in a chaotic mode, which greatly impacts the control performance, or even leads to system breakdown. As chaotic behaviour is random-like, probability methods are applicable to analyse chaotic systems.



Chaotic map, bifurcation and IPD at $\alpha = 1, 52$

In [1,2,3,4], a DC-DC converter with a simple chaotic map is studied. When it operates in a chaotic mode, the invariant probability distribution (IPD) of the chaotic map is calculated using the eigenvector method. Comparing the IPD on the right side of the figure with the chaotic map depicted on the left and its bifurcation shown in the middle, we can see that they are consistent. Thus, the calculation of the IPD is correct, and can be used to estimate the power spectral density of the inputs or outputs, which specifies the level of electromagnetic interference (EMI) of the DC-DC converter, to calculate the average switching frequency (ASF) of the DC-DC converter, which indicates the decrease of the ASF that has only be observed before when the system operates in a chaotic mode, and to determine the parameters, under which the system exhibits chaotic behaviour. For instance, applying the invariant density distribution to estimate the ASF of the boost converter yields the expression $\langle s \rangle = \frac{2}{1+\alpha}$, where $\alpha = \bar{V}_O \setminus V_I - 1$. When system operation is periodic, i.e., $\alpha = 1$, thus $\langle s \rangle = 1$; while the system operates in chaotic mode, i.e., $\alpha > 1$, thus $\langle s \rangle < 1$. The values α and $\langle s \rangle$ are inversely proportional.

References:

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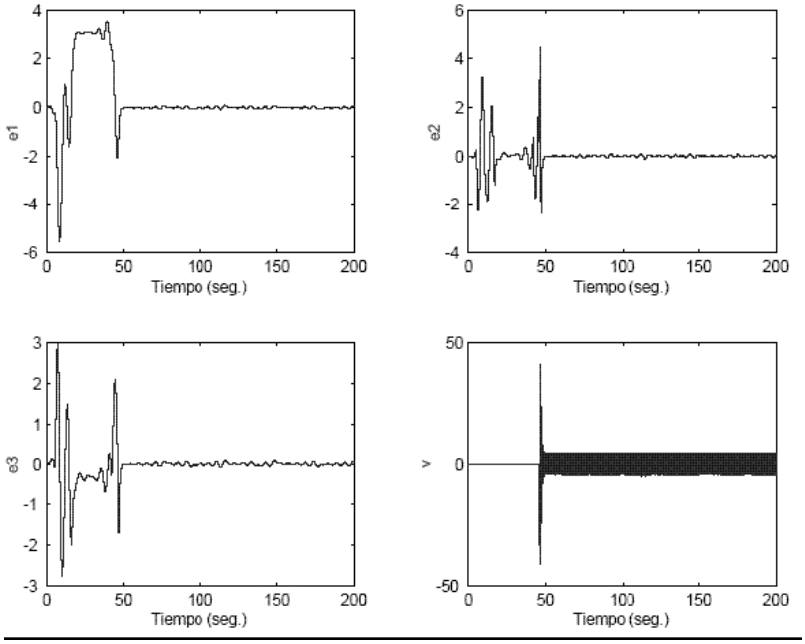
Synchronisation for Linear Piecewise Chaotic Systems

J.G. Barajas Ramíirez, D.I. Rosas and J. Alvarez

Chaos synchronisation has important applications, such as in private communication, which involves to encode or encrypt information through a chaotic signal that is sent to a receiver, where a chaotic system is synchronised to recover the information. Sprott proposed a practical chaos generator constructed by a very simple circuit with a piecewise linear function. There are some proposals to solve the synchronisation problem of this type of systems, such as feedback linearisation control techniques. However, they only work well in the case of identical systems where there are no parametric perturbations or external disturbances. In practice, such conditions are very hard to satisfy.



Robust synchronisation of two Sprott circuits

An algorithm aiming to achieve identical synchronisation of two Sprott systems $\frac{dx}{dt3}+a\frac{dx}{dt2}+\frac{dx}{dt}=G(x)$, where $G(x)$ can be one of the piecewise linear functions, $b|x|-c$, $-b\max(x,0)+c$, $bx-c\text{sign}(x)$, and $-bx+c\text{sign}(x)$, interconnected as master and slave is presented and experimentally proven in [1]. They must have the same structure, but not necessarily the same parametric values, and matched bounded perturbations may also be present. A sliding mode control technique is used to design the coupling signal $v=F(t,e)\text{sign}(S)$, where $S=a_1e_1+a_2e_2+e_3$, and $F(t,e)=a_1|e_1|+a_2|e_2|+a_3|e_3|+a_4$. Therefore, the closed loop system is robust against external perturbations and parametric variations. In theory, one can attain asymptotic identical synchronisation in spite of the existence of this kind of disturbances. However, in practice, as a result of a discontinuous coupling signal, there will be a small chattering in the synchronisation errors. Nevertheless, in many applications this error may be negligible.

Reference:

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Emerging Convergence in the Open Source Initiative CampusSource

Prof. Dr. Kaderali, Michael Stepping

The Ministry of Science and Research of the Federal State of North Rhine-Westphalia supports the development of virtual university systems, which consist of multimedia contents and technical infrastructure. The state initiated a process which includes the construction and development as well as operation of an infrastructure for computer and web-based learning and teaching. The process as a project supports and welcomes the set-up of cooperative networks in universities and with industrial partners to a broad use. Introducing the Open Source strategy, the Ministry takes up the academic tradition of presenting results of latest research in a suitable form. Within the academic tradition, scientific results are described as exactly as possible to allow for the verification by third parties.

The aim of the Open Source initiative is to unite the efforts of several projects and make the results freely available for use and further development to those who are interested. Each system developed is freely available under the CampusSource license. This license enforces the publication of all source code and allows every licensee to modify the code as long as every modification is returned into the public software pool. There is no license fee for the use of the software, which is called "free software".

Another advantage of the availability of source code is the adaptability of the program to the user's individual needs including functional extensions and adjustments to new technologies. Users of Open Source software can modify the source code at any time, and therefore be independent from manufacturers.

Success of CampusSource Criteria for success of CampusSource are a wide distribution of the software and acquiring dedicated and competent developers to improve the software. Therefore CampusSource publishes the software products nation wide as well as internationally. Directions of software development have to be put forward through discussion with all engaged users and developers.

This includes development and use of a decent reference architecture for infrastructure-software in educational institutions. In addition to that a quality standard has been defined and achieved. CampusSource has prooved itself as a high quality level organization which supports and leads the development of technical platforms for operating virtual universities.

To achieve these aims the initiative created an internet portal at `www.campussource.de`. Integrated into the portal is the "software exchange market". This is an area where software is available for download including all documents, demos, installation scripts, documentation and test cases.

Future of CampusSource The emerging need of access to external data sources like university databases (students, professors), HIS or SAP lead to the set-up of the `CampusSource Engine` working group CSE. This working group identifies common functionalities of platforms and systems. The architecture for the collaboration and message interchange of the systems is under research and development. A first paper introduces to this interesting research area. (`http://www.campussource.de/projekte/hiscse`)

Security and Privacy Aspects in Mobile Agent Systems

Biljana Cubaleska

Agents are autonomous programs which try to reach their goals in changing environments. Mobile agents open a new dimension to software design and extend the traditional agent technology. They are considered to have great potential for Internet based electronic markets. The owner of an agent can instruct it to visit many hosts in a network, and thereby execute some desired tasks for him. After having carried out the instructions, the agent returns to its home and delivers the results it collected during its journey to its owner.
However, the mobility raises new security threats for all involved parties. Both the visited hosts and the agents are exposed to serious dangers from the opposite side - the mobile agent can attack the host and the host can attack the mobile agent. A visit from an agent is a security risk for the visited host: e.g., a malicious agent can have some undesired functionality like a Trojan horse and try to get unauthorized access to resources, for instance reading private information, or even altering or deleting it. It can also disrupt operations of the host platform and thereby execute a denial of service attack against the host. There are also various possibilities for malicious hosts to attack agents and thereby the agent owners. These attacks can focus on the extraction of private information, stealing digital goods, modifying agent data, or even destroying the agent.
In the last several years we have analyzed many of the security threats and proposed some solutions, especially for protecting agents against malicious hosts. But protecting a host against a malicious agent is also quite a demanding task: The main problem with mobile agents from hosts point of view is that one can never know what mobile agents are going to do within the host computer. Some host protecting techniques have been proposed in the literature, but none of them gives enough protection with regard to preventing attacks from malicious agents. Most of them are actually *a-posteriori* signature-based detection methods, i.e. hosts only accept agents signed by their owners, and if something illegal happens, the source of "evil" can be identified.
But the permanent use of digital signatures opens tracing possibilities for agents and compromises the privacy of their originating host. Integrating strong security mechanisms in a mobile agent system usually implies the possibility for tracing the actions of an agent belonging to some owner and thereby building a profile of its actions. Therefore, designing practical privacy mechanisms in a mobile agent application by maintaining some security goals at the same time is a challenging task.
We have developed some techniques to protect the privacy of the agents and their originating hosts, providing some kind of anonymity. But it is more important that these techniques allow revocation of the anonymity in the case of illegal actions, so that accountability is provided. We call this kind of privacy "accountable privacy" or "fair privacy". The techniques can be classified according to the basic cryptographic primitive was used to implement the revocable anonymity:

- Privacy techniques based on digital pseudonymes,
- Privacy techniques based on group signatures, and
- Privacy techniques based on ring signatures.

All three solutions for the accountable privacy problem have some advantages and disadvantages with regard to the security and the efficiency of the scheme. They have been analysed and then compared with each other, so that a specific technique can be chosen according to the given mobile agent application.

A Modular Namespace-Aware Ontology for E-Learning Contents and its Implementation as an XML Schema

Gerd Steinkamp

During the last couple of years, XML has become a widely employed standard which has greatly fueled innovation in the information technology sector by facilitating data exchange between independent parties and lowering costs for technology implementation and integration. Many communitites, organisations and enterprises have created data models based on the XML standard and some of them have evolved as standards for specific domains, such as DocBook (OASIS) and DITA (OASIS) for technical documentation projects, SCORM (Sharable Content Object Reference Model, ADL) for exchange of learning objects, or MathML (W3C) for the notation of mathematical contents. Although some standards have evolved in the domain of e-learning, such as LOM, SCORM, QTI, none of these provide a comprehensive vocabulary as required for semantically enriched authoring of complex e-learning contents.

In addition to the technical standardisation as provided by SCORM, the successful implementation of a content sharing process requires the establishment of a common ontology within the domain of e-learning. This means that fundamental concepts and their relations between each other must be identified and a clear definition has to be provided if content modules should be shared among institutions which have no common organisational link. Only such an ontology allows the efficient sharing and re-use of contents since it provides the means to create documents with a clear explicit semantical structure instead of implicitely providing meaning through subjective devices of formatting and styling.

Within the CampusSource community the need for a content exchange standard was identified and a working group was established to develop a solution that facilitates the exchange of documents, allows utilisation of common authoring tools, and increases user acceptance for the community platforms.

The following requirements towards the community standard were identified: 1. the XML schema should not only support e-learning contents, but also other scientific and non-scientific documents, such as dissertations, reports, etc. 2. The schema should be modular and extensible with regard to topic-specific concepts from different domains, such as social sciences, mathematics, law, engineering, and computer science. 3. The standard should allow established individual namespaces to be used and to be mapped to the common ontology. This feature is important because the requirement for individual namespaces is evident and results from cultural and organisational differences between institutions. For example, the XML element names “p”, “para”, or “absatz” while coming from different namespaces are all related to the same definition which is provided by the ontology concept “Paragraph”.

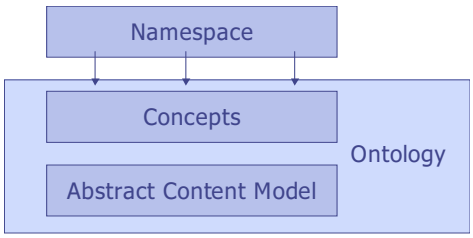

Fig. 1:

On the Application of Multivariate Statistical Analysis Methods in Intrusion Detection

Alex Essoh

The topic Intrusion Detection has been of great interest for the past ten years. Not surprisingly when the dramatic increase of incidents and vulnerabilities over the past ten years is taken into consideration. There has been an increase of a factor 32 in vulnerabilities [1]. Therefore ways have to be found in order to analyse, detect and anticipate dangers and attacks and it has to be specified how to react in case an attack occurs (Intrusion Response).

The idea behind the technique of detecting intruders is that when an intruder gets into a third party system, he leaves traces behind or behaves differently compared to the normal user. This means that if methods or mechanisms can be found to carefully analyse the data produced, there is a greater chance of detecting a violation of the system policy and hence the intruders. Depending on how the data is collected and analysed we speak of Host-based Intrusion Detection Systems (HIDS), where the software is installed on a single host or of Network based Intrusion Detection System (NIDS), whereby the IDS Software monitors a network segment or a complete network.

To detect attacks on information systems, basically two approaches can be distinguished: Anomaly Detection (Statistical Approaches, Bayesian Networks, Neural Networks, etc.) and Misuse Detection (Pattern Matching, State Transition Analysis, etc.). In Anomaly Detection a profile of the variable to be analysed is made e.g. the use of resources (CPU) or typical user behaviour (login behaviour), this is also called the long term profile and is compared with the actual realisation of the variable (short term profile). If the difference between long term and short term behaviour exceeds an a priori defined threshold, the event can then be seen as an anomaly [2].
A different approach is followed in Misuse Detection whereby attack specific signatures are stored in the signature database. The data stream is then systematically analysed by searching for these attack signatures in the data stream.

At the Department of Communication Systems in Hagen, various existing approaches, univaritate and multivariate analysis methods (Chi-Square Test [3] and Hotelling Test [4]) are being systematically analysed with regard to their ability to detect anomalies. Furthermore, new approaches are being carefully studied and applied. We will concentrate on the use of robust statistical methods and multivariate analysis methods to detect anomalies.

[1] CERT Coordination Center http://www.cert.org/

[2] Dorothy E. Denning, An Intrusion Detection Model, IEEE Transactions on Software Engineering, **13** *2* (1987), 222–232.

[3] Nong Ye and Qiang Chen, An Anomaly Detection Technique based on a Chi-Square Statistic for detecting intrusions into information systems, Quality and Reliability Engineering International, **17** (2001), 105–112.

[4] Nong Ye Nong, Syed Masum Emran, Qiang Chen, Sean Vilbert, Multivariate Statistical Analysis of Audit Trails for Host-Based Intrusion Detection, IEEE Transactions on Computers, **51** *7* (2002), 810–820.

Anonymity and Privacy in Peer-to-Peer Networks

Thorsten Kisner

In communication networks three types of anonymity can be considered: sender anonymity, recipient anonymity and a combination of both. In an instant messaging network people normally want to know to whom they send messages and from whom they receive them, so from the participants point of view the unobservable relationship between them is the most important aspect.

In the established instant messaging networks like Yahoo, AOL, ICQ or MSN the participants have to trust each network operator, who exactly knows about each communication link in their network. In these networks there is normally no end-to-end encryption available, only an encryption to the server using TLS/SSL is available. In open instant messaging networks with standardized protocols like the Extensible Messaging and Presence Protocol (XMPP) [1] it is easy to add an own cryptographic layer to gain end-to-end security. Since XMPP is still a centralized protocol, the server operators still have to know about all participants of communication to be able to deliver the message to the correct receiver. This issue can be characterized as a routing problem.

This problem has been addressed in many P2P networks by providing mechanisms to store data distributed within the whole network. Systems like CHORD [2] or CAN [3] are based on a distributed hash table which is organized in a different structure in each system. In both P2P networks (and many other proposals for P2P lookup services) an efficient routing algorithm is used to forward the query to the node on which the information is stored.

On the other hand a number of protocols have been proposed for anonymous network communication such as Crowds, Onion Routing, Mixes and DC-Networks. Normally there is a tradeoff between anonymity and scalability of the system. DC-Networks for example provide quite a good degree of anonymity but the scalability is really poor. Mixes on the other side are scalable but generally the user has to trust each mix operator.

At the Department of Communication Systems in Hagen different anonymity network protocols and P2P network structures are being investigated to find a convenient combination suitable for anonymous real time communication in an instant messaging network with minimal trust requirements from the user to the network.

[1] Jabber Software Foundation http://www.jabber.org/

[2] Ion Stoica, Robert Morris, David Karger, M. Frans Kaashoek, Hari Balakrishnan: *Chord: A Scalable Peer-To-Peer Lookup Service for Internet Applications.* Technical Report TR-819

[3] S. Ratnasamy, P. Francis, M. Handley, R. Karp, S. Shenker: *A scalable content-addressable network*

A Naming Service Architecture and Optimal Periodical Update Scheme for a Multi Mobile Agent System

Suphithat Songsiri

Communication, by means of exchanging information and knowledge sharing, is paramount for mobile agents to collaborate with one another. A mobile agent communication, e.g. messaging, can only occur when the actual location of the mobile agent is known and a reliable message delivery scheme is utilized. This research concentrates on designing a globally distributed naming service architecture, which aids in locating a mobile agent and finding the optimal time threshold for periodical location update scheme. To locate a peer mobile agent, the following three processes must eventuate: name resolution, location update and searching or tracking scheme. The name resolution process comprises of an entity sending the name of a mobile agent to a name server, and the name server returns the mobile agent's latest update location. In the location update process, a mobile agent sends its current position to a name server. Searching is a procedure, where an entity, after retrieving a mobile agent's location from a name server, performs a broadcast scheme to find the target mobile agent. The tracking scheme is a method where each visited host maintains some information, e.g. forwarding pointer, leading to the actual location of a mobile agent. The well-known hurdle of designing a positioning system is the mobility of a mobile agent. A location update algorithm alone is inadequate to guarantee the accuracy of the actual location of a mobile agent. In order to escalate the accuracy of a target mobile agent's location, a coalescence of location update algorithm with either the tracking or the searching algorithm should be effectuated. This research concentrates solely on the periodical location update algorithm and tracking (forwarding pointer) algorithm consortium. This research uses a Geographically Distributed Naming Server Clusters (GDNSC) as a naming service architecture, which performs naming resolution. From a distributed architecture of GDNSC, to select a service point, this research proposes a server selection scheme based on the combination of round trip time (RTT) and the number of hops (N). A service point will be chosen when it shows the minimum of $(\alpha \cdot RTT + \beta + N)$ where $\alpha + \beta = 1$. The optimal time threshold aims to minimize the sum of the cost of periodical updates and the cost of maintaining forwarding pointers. To calculate both costs (i.e. cost of periodical update and cost of maintaining forward pointers, this research applies probability theory (i.e. especially, random variable and probability function) and renewal theory.

Chair of

OPTICAL INFORMATION TECHNOLOGY

(Lehrgebiet Optische Nachrichtentechnik)

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Talbot's bands as a refractive-diffractive phenomenon

J. Jahns, A. W. Lohmann*, M. Bohling

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An interference experiment described by Talbot in 1837 [1] on the formation of interference fringes in white light has gained relatively little attention so far. In that experiment, Talbot observed the formation of interference fringes ("Talbot bands") in one of the two first diffraction orders of a grating spectrometer upon inserting a piece of glass of appropriate thickness halfway into the illuminating beam (Figure 1). This observation is somewhat surprising, in particular, the fact that the bands occur only in the +1st order (notation as defined in the figure) and not in the −1st order. The occurence of the interefference fringes in the +1st order can be explained qualitatively in the temporal domain [2]. Here, we have a two-fold interest in the Talbot band experiment: first, we explain it as a refractive-diffractive phenomenon, second, we extend the experimental setup by introducing structured elements.

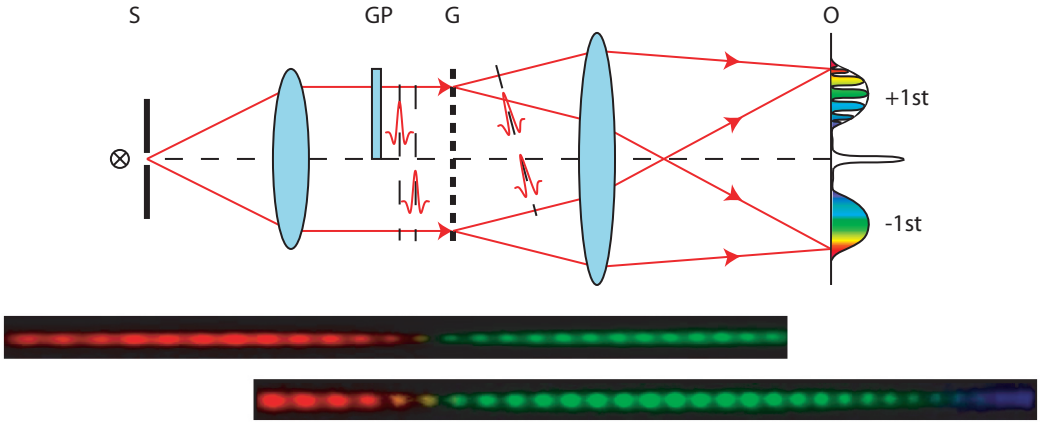


Fig. 1: Experimental setup for the observation of the Talbot bands: a diffraction grating G is illuminated by a colliminated beam of white light from source S. A glass plate GP is inserted half-way into the illuminating beam. In the output plane O of the grating spectrometer bands are observed only in the +1st order. The bands in the +1st order are shown for a simple glass plate and for a stepped wedge as the object.

The delay between the two pulses shown in the figure is given as $\tau = \tau_r + \tau_d$ where τ_r is the"refractive" delay introduced by the glass plate and τ_d is the "diffractive" delay due to diffraction. It is

$$\tau_r(\nu) = \frac{\Delta n(\nu) l}{c} \quad \text{and} \quad \tau_d(\nu) = -m \left(\frac{N}{2}\right) \frac{c}{\nu} \tag{1}$$

where m denotes the diffraction order. Fringes are observed if the total delay is approximately zero. Depending on the dispersion behaviour (normal or anomalous for τ_r, positive or negative sign for τ_d depending on m), one can implement different experimental configurations [2]. Here, we demonstrate an experimental extension of the classical experiment. If, for example, the glass plate is replaced by a staircase-like wedge, one observes a different modulation of the bands (see figure). In particular, they get more pronounced. This situation can be understood as the occurence of multi-beam interference as compared to two-beam interference in the case of the simple glass plate.

[1] H. F. Talbot, An experiment on the interference of light, *Phil. Mag.* **10** (1837) 364

[2] A. W. Lohmann, ch. 6 in: *Optical information processing, part II*, Uttenreuth (1979).

Mask optimization for halftone-based gray-scale lithography

J. Jahns, W. Hanke, M. Gruber, Th. Seiler

The fabrication of refractive or reflective microoptical elements with (quasi-) continuous surface profiles can be achieved in two different ways: first, by using a gray-level mask like, for example, HEBS masks [1, 2]. Another approach is to use binary masks and optical measures to generate a gray-scale intensity distribution. This has been demonstrated, for example, by using halftoning [3], well known from newspaper printing.

For the halftone technique, the mask is subdivided into cells, each of which has a certain transmission value. The same transmission can be achieved with many different cell designs. Here, we focus on optimizing the cell designs for the purpose of generating microoptical elements. Criteria for the optimization of the mask are achievable smoothness of the phase profile, achievable linearity, and quality of the edges. Several cell designs were tested optically and experimentally. Four different design patterns are shown in Fig. 1.

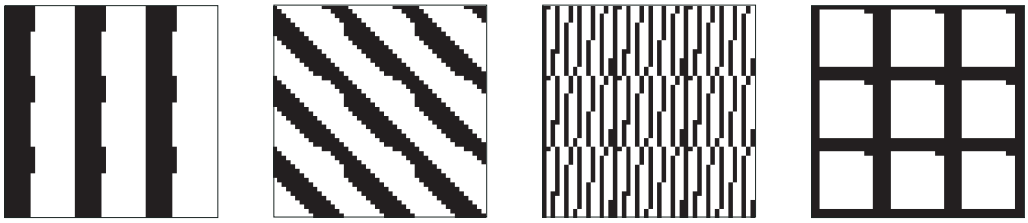


Fig. 1: Four different cell designs with the same transmission factor (3×3 cells are shown).

As a first simple test a linear wedge was generated. Fig. 2 shows the mask pattern and Fig. 3 shows the fabricated profile in photoresist (thickness). The intensity distribution falling onto the photoresist during the lithographic fabrication was generated by the low-pass characteristic of free-space propagation.

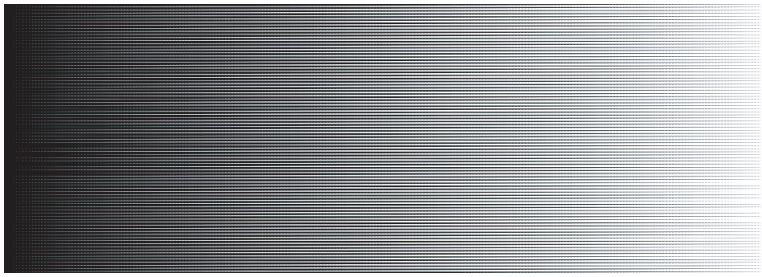


Fig. 2: Linear wedge with 256 gray levels.

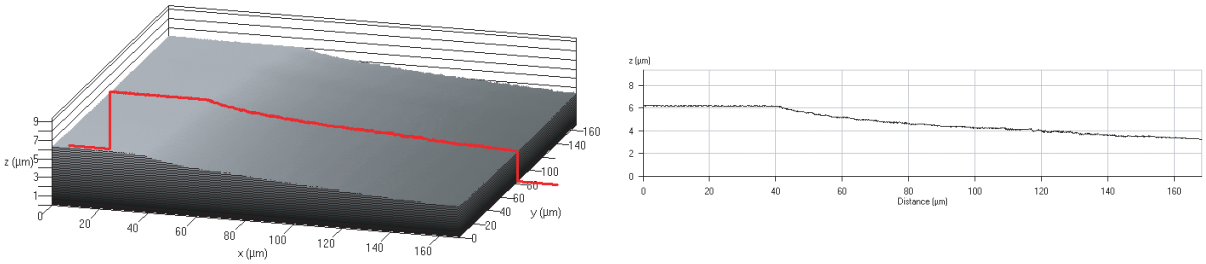


Fig. 3: Linear wedge in photoresist.

[1] W. Däschner et al., *Appl. Opt.* **36** (1997) 4675

[2] Ch. Gimkiewicz et al., *Appl. Opt.* **38** (1999) 2986

[3] K. Reimer et al., *Proc. SPIE* **3226** (1997) 2

Experimental tests on the 3D free-space optical multilayer

M. Jarczynski, J. Jahns

In a previous article of this annual report we have described the design and the assembly of the 3D free-space optical multilayer [1]. Here we present the experimental test setup and first results for the array imaging towards the opposite module side. Due to the fact that currently no appropriate MCM and PCB is available, the 3D optical multilayer is tested by actively aligned metal-interface plates (MIP) with MT-sockets for fibre-bundles. The MIPs were fabricated by micro-machining and have tolerances less than 10 μm. In Fig. 1 the inserts (1) and (2) show the frontside MIP with four MT-connectors inserted and the 3D free-space optical multilayer module aligned to this MIP, respectively.

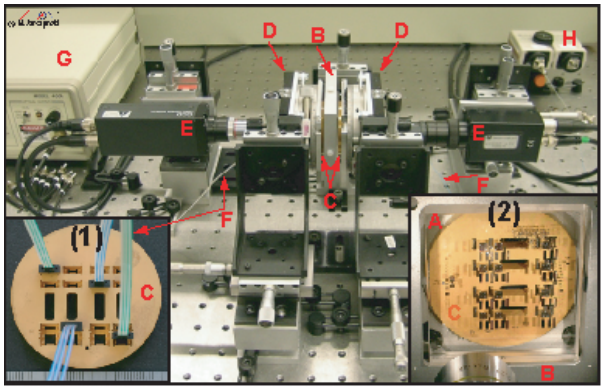


Fig. 1: The experimental test setup for the 3D optical multilayer. Key-Code: A – 3D free-space optical multi-layer, B – chuck for optical module, C – MIP, D – gimbal mounts for MIPs, E – observation CCD-camera, F- fibre-bundles, G – laser-transmitter, H – photo detector.

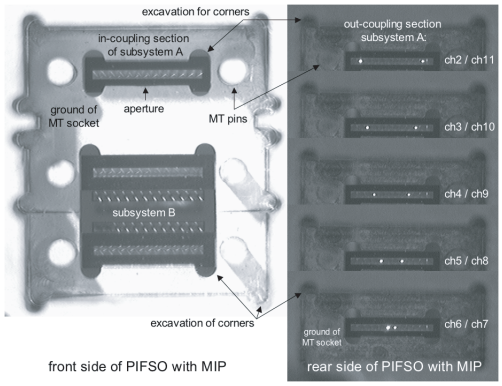


Fig. 2: Fig. 2: The photos show the optical coupling elements on the module and the aligned MT-sockets around. In the right column several pictures show the out-coupling area on the opposite side of the module with different active channels.

Fig. 2 shows the results that are accomplished by the array imaging system that performs the interconnection towards the opposite side. The pairs of active channels can be identified very well and a first measurement leads to an average efficiency over all 12 channels of −7.73 dB, whereas the values are in a range between −7.37 dB and −8.31 dB. This means that the optical path has approx. 2.5 dB more loss than theoretically determined for the worst case. However, for a prototype with such a high complexity in design and packaging this is a good result. This is also underlined by the eye-diagram (see Fig. 3) that is recorded with a test code at 250 Mbit/s. The open eye is visible in evidence.

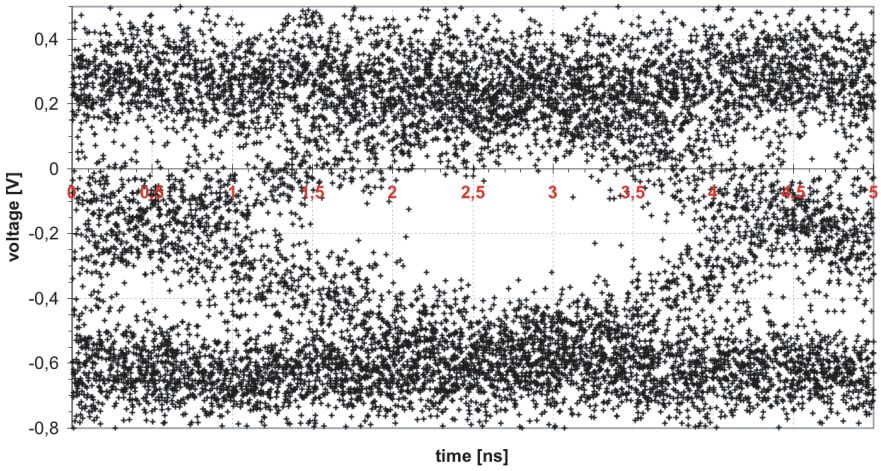


Fig. 3: The diagram shows a test-sequence at a frequency of 250 Mhz. The noisy signal is mainly influenced by the used PIN-Detector that is not optimally appropriated for this measurement.

[1] M. Jarczynski, J. Jahns, “A 3D free-space optical multilayer”, this Annual Report

Highly efficient P2P-interconnect

M. Jarczynski, Th. Seiler, M. Bohling, J. Jahns

A P2P-interconnect module for a free-space optical interface in the CPU-MEM-bus in the HOLMS-project was fabricated. Attention was paid, in particular, to reduce errors in the fabrication chain. Due to a one-step process for silver and aluminum coating by an e-beam evaporation the efficiency and reliability of the reflective coatings was increased. Other issues were the use of highly planar substrates and the optimization of alignment marks for the multi-mask lithography processing. The experimental test of this module confirms the high quality of this PIFSO-module.

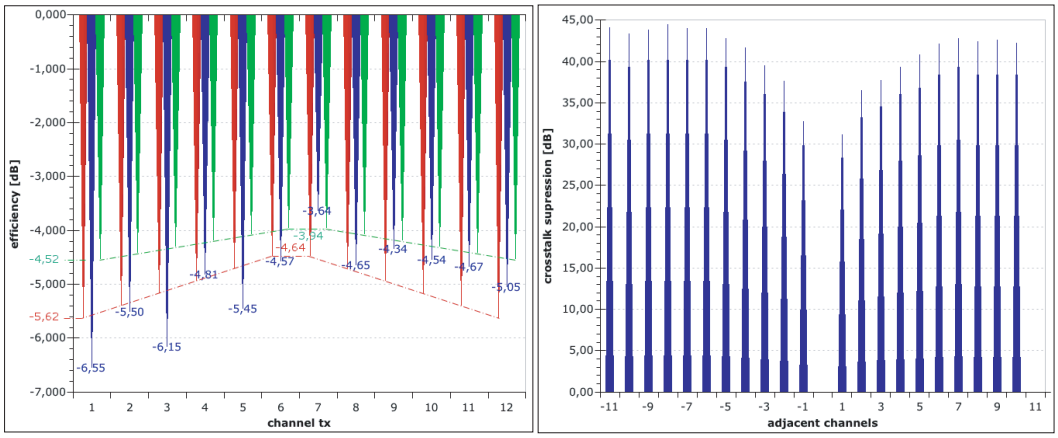


Fig. 1: Left – The efficiency of each channel of the PIFSO module D6.1-4 in singlemode operation. The displayed blue values are means of 10× measurement. The red labelled values show the theoretically calculated efficiency of a homogenous illuminated square in-coupling lens fabricated with four phase levels. The green labelled values present a fully eight phase level in-coupling element with the same illumination. Due to the experimental test a beam with nearly Gaussian intensity and approx. 236 μm diameter ($I \sim 1/e^2$) was used, so that the measured values should be found in between the red and green labelled theoretically calculated values. Right – The crosstalk to adjacent channels in single mode operation. Presented are the mean values of crosstalk suppression of channel $n = 1, 2, \ldots, 12$ to the adjacent channels $n + / - x (x = +/ - 1, +/ - 2, \ldots, +/ - 11)$.

The setup for the efficiency test of the PIFSO module was similar to that one described in [1]. Attached to the detector, a GRIN multimode fibre bundle (62.5/125, NA=0.27) was used. The calibration measurement is realised by measuring the optical power by butt-coupling the two fibres bundles via MT pins. After insertion of the PIFSO module or the PCB-embedded waveguides the absolute power transfer is measured. Each measurement was finished by a check of the source power to document its stability. The efficiency of the inserted modules is calculated by η_{module} [dB] = P_{module} [dBm]−P_{butt} [dBm].

The calibration measurement was repeated eight times. The measurements show a standard deviation of 0.07 to 0.5 dB. After inserting the PIFSO module and an optimal alignment of the MT-connector 10 power-measurements per channel are accomplished. The standard deviation during the 10 measurements lies between 0.08 and 0.32 dB. The results for the efficiency and the crosstalk suppression are shown in Fig. 1. For a better comparison of the measured values the theoretically estimated values for each channel are also shown. Theoretical and experimental values are in good agreement. The cross talk suppression is better than 31 dB.

[1] M. Jarczynski, Th. Seiler, R. Hemning, M. Gruber, J. Jahns, “Experimental specification of a P2P-inrterconnect for a CPU-MEM-bus”, Annual report 2004

Experimental specification of a PIFSO-OE-PCB interconnect

M. Jarczynski, M. Bohling, J. Jahns P. Beil (ILFA GmbH), O. Stübbe, J. Schrage (C-Lab, Siemens-SBS)

The highly efficient P2P-interconnect module described and specified in a previous article of this annual report [1] was connected to PCB-embedded waveguides in laboratory environment. The alignment was realized actively by using the outer channels and the components (PIFSO-module and laminated wavguides) were held by mechanical gimbal mounts. The experimental results for efficiency and crosstalk were detected as it is described in [1] and are shown in Fig. 1. Except for channel 8, that is obviously an outlier, the average value of all channels is −9.0 dB, lying within a range from −6.5 dB to −9.74 dB. In comparison with the stand-alone PIFSO measurement the efficiency is reduced by around 4 dB which results (as far as the measurement is repeatable) from the absorption loss in the waveguides and the Fresnel loss. The values for these losses are in agreement with the measured values of the laminated waveguide sample.

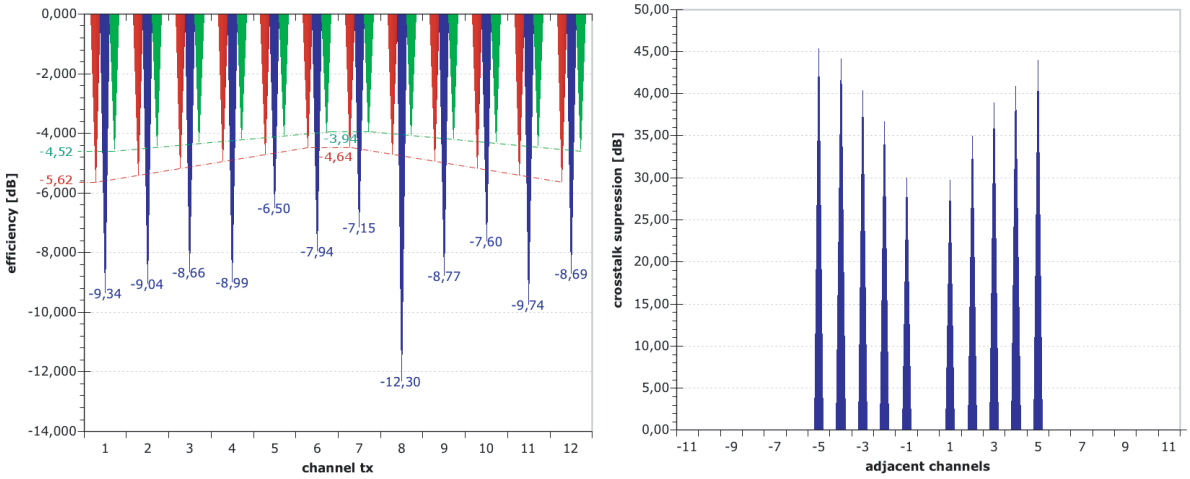


Fig. 1: Experimental results of an interconnection via a PIFSO-module and PCB-embedded waveguides: left – efficiency, right – cross-talk supression. A range of theoretically possible efficiency for the rate of the PIFSO-module is given by the dotted line. A crosstalk over more than 5 channels was not measurable.

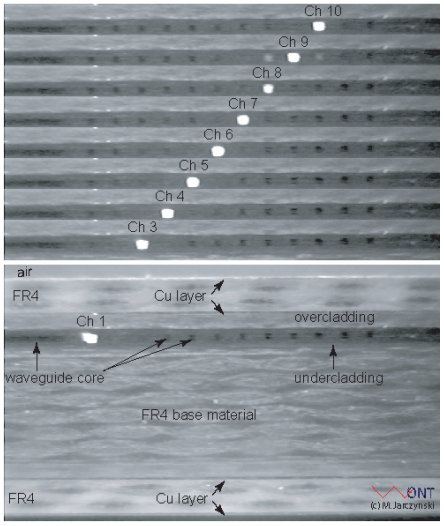


Fig. 2: Bottom – A cross section of the PCB-embedded waveguides with active channel 1. Above – sections of photographs with different active channels.

In addition to the efficiency and crosstalk specification in laboratory environment the mechanical alignment and assembly concept was tested with a similar PIFSO-module and a specially milled PCB. Currently a patent is pending so that the setup could not be presented. The qualitative results of coupling light from an MT-fibre-bundle via the PIFSO module that is inserted and aligned into a PCB with embedded waveguides are shown in Fig. 2 and confirm the function.

[1] M. Jarczynski, Th. Seiler, M. Bohling, J. Jahns, "Highly efficient P2P-interconnect", this Annual Report

A 3D free-space optical multilayer

M. Jarczynski, J. Jahns

The idea of merging the concepts of planar-integrated free-space optics (PIFSO) and stacked planar optics (SPO) was presented in a contribution of the last Annual Report [1]. In the recent year we have brought the concept to application and can now present an assembled and tested 3D free-space optical multilayer. The module represents an optical interface for 192 channels between opto-electronic components (laser diodes and photo detectors) on an opto-electronic multichip module (MCM) and fibres-bundles or PCB-embedded waveguides. The planed setup and the used optical design are illustrated in Fig. 1.

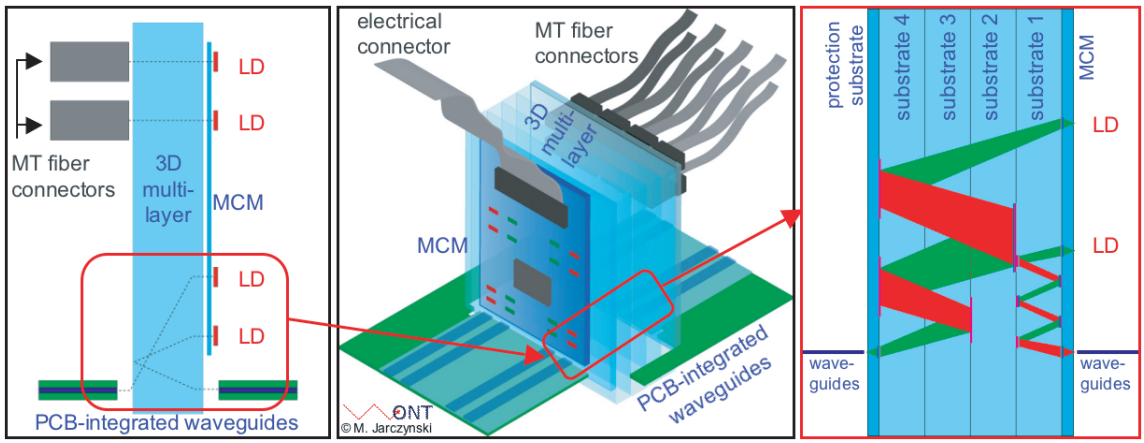


Fig. 1: From left to right: The principal interconnection scheme, the planned packaging and the basic optical design: An array imaging and a multi-channel approach for opposite and same side interconnection, respectively.

Due to the stacking of four substrates with functional surfaces and two protection substrates the packaging complexity is large. For the alignment of the substrates we have used a method described in [2]. For it we have modified the mask holder and the substrate chuck of the maskaligner Suess MA4. The mechanical system of the MA4 was used for a stable alignment and the UV-source for the curing of a low-viscose optical glue (Bohle B665-0). For the inner surfaces of substrate 1 to 4 glue was applied across the whole area, while the protection substrates were glued only at the corners in order to avoid that glue can contaminate the structures of the transmissive optical elements on the outer surfaces. The assembled 3D free-space optical multilayer module is shown in Fig. 2. The experimental results are presented in a following contribution of this Annual report. More information can also be found in [3].

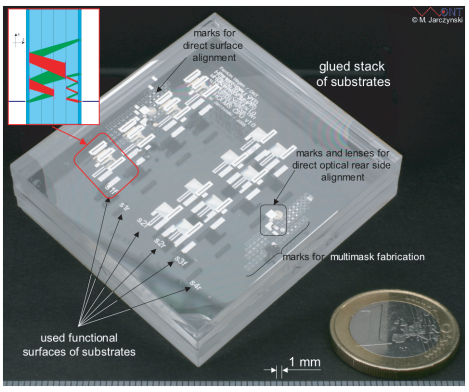


Fig. 2: The assembled 3D free-space optical multilayer module connects 192 channels.

[1] M. Jarczynski, J. Jahns, "Designing a 3-D optical multilayer due to merging the concepts of stacked and planar-integrated free-space optics", Annual Report 2004

[2] M. Gruber, D. Hagedorn, W. Eckert, "Precise and simple optical alignment method for double-sided lithography", *Appl. Opt.* **40**, pp. 5052–5055, 2001

[3] M. Jarczynski, J. Jahns, "Ein optischer 3D-Multilayer: Die Verschmelzung von "gestapelter Optik" und "planar-integrierter Freiraum-Optik"", Workshop "Optik in der Rechentechnik", Sept. 2005

Temporal impulse response of the Talbot interferometer

H. Knuppertz, J. Jahns

To verify earlier theoretical work [1] we measured the temporal impulse response of the Talbot interferometer with Gauss-shaped ultrashort pulses of 30 femtoseconds duration. For this research we could use the facilities of the Max-Born-Institut in Berlin, where an ultra short pulse laser source is available and the fs-pulses can be detected with an optical autocorrelator. To prepare the experiments we studied the features of the measurement equipment and designed suitable phase grating and fabricated them in our clean room. We set up the Talbot interferometer in our laboratory and performed some functional tests to ensure that we can expect reasonable results by transmitting ultra short pulses via the interferometer.

The Tabot interferometer consists of two phase gratings, the first one diffracts an incident plane wave, a second grating placed in line recombines the diffracted wave field to a plane wave. Between the harmonic parts of the diffracted wave field travel different distances resulting in different time delays τ_n. Here, n denotes the n-th diffraction order. pass increasing long propagation paths. The temporal impulse response is described as:

$$h(t) = \sum_{n=0}^{N} |a_n|^2 \delta(t - \tau_n) = \sum_{n=0}^{N} |a_n|^2 \delta(t - n^2 \tau_1) \tag{1}$$

The coefficients a_n are determined by the grating structure. For the paraxial case it is easy to show that $\tau_n = n^2 \tau_1$. Since ultra short pulses cannot be measured directly we need to use an optical autocorrelator that operates the following integral:

$$I(\tau) = \frac{1}{T} \int_{-T/2}^{T/2} \left| (E(t) + E(t+\tau))^2 \right|^2 dt \tag{2}$$

with $E(t)$ the incident wave field arriving from the interferometer and $E(t+\tau)$ a delayed part of it. For the used setup we simulated the autocorrelators output that is illustrated in Fig. 1. For better perceptibility the curve is plotted with its envelope only omitting the carrier (bold line). The oscillating curve between the calculated envelope in Fig. 1 is the result of the measurement including the carrier. The pattern overlay shows good consistency. The most essential result is the good agreement of the temporal delays by calculated and measured curve. It confirms the expected quadratically increasing delay times for the Talbot interferometer and their absolute values.

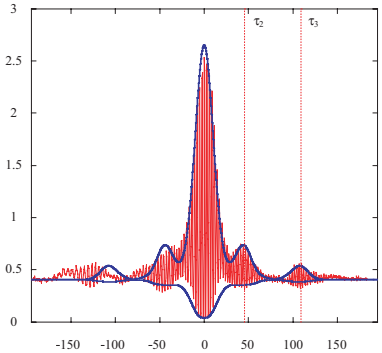


Fig. 1: Measured autocorrelation (with carrier) and modelled autocorrelation (envelope only). Horizontal axis in femtoseconds, vertical axis in normalized (arbitrary) units. The first order pulse is hidden in the main central peak.

[1] J. Jahns, A. W. Lohmann, "Temporal filtering by double diffraction", *Appl. Opt.* **43** (2004) 4339–4344.

[2] H. Knuppertz, J. Jahns, R. Grunwald, "Ultrafast optical tapped-delay line using the self-imaging effect - recent experiments", *ORT 2005*, Ilmenau, 23. September 2005.

Measurement of the power spectrum of the Talbot interferometer

H. Knuppertz, J. Jahns

The Talbot interferometer and the related Montgomery interferometer are expected to be suitable devices for temporal filtering purposes in optical information processing. One approach to discover its relevant temporal characteristics is to measure its power spectrum. An alternative procedure is to measure the temporal impulse response with ultra short temporal pulses [1]. This choice is presented elsewhere in the annual report. Temporal impulse response (eq. 1) and frequency response (eq. 2) are related by the Fourier transformation. The temporal impulse response for any double grating setup can be formulated with some straight forward considerations [2]. The physical dimensions of the gratings determine the coefficients a_n and the delay times τ_n. In our experiments we used two identical gratings that are placed in line in a multiple of the self-imaging distance. The impulse response of this configuration is:

$$h(t) = \sum_{n=0}^{N} |a_n|^2 \delta(t - \tau_n) = \sum_{n=0}^{N} |a_n|^2 \delta(t - n^2 \tau_1) \tag{1}$$

and the corresponding frequency spectrum is:

$$H(f) = \sum_{n=0}^{N} |a_n|^2 \exp[2i\pi n^2 \tau_1 f] \tag{2}$$

In these expressions the term $|a_n|^2$ occur because the light passes two gratings and any phase shift is compensated. For gratings delay times τ_n increases quadratically. Other diffractive objects can be designed with a linear increase [3]. Since optoelectronic sensors are phase blind we can only detect intensities so we measured the power spectrum $|H(f)|^2$. Two curves for the power spectrum of the Talbot interferometer are presented in Fig.1. The calculated curve progresses fidgetily while the measured curve passes more smoothly. The cause for this observation is a low pass characteristic of the measurement equipment. However, it is obvious that calculated and measured curve are in good agreement. This measurement confirms the theoretical considerations that are now sustained by results obtained in the temporal domain and in the frequency domain here reported.

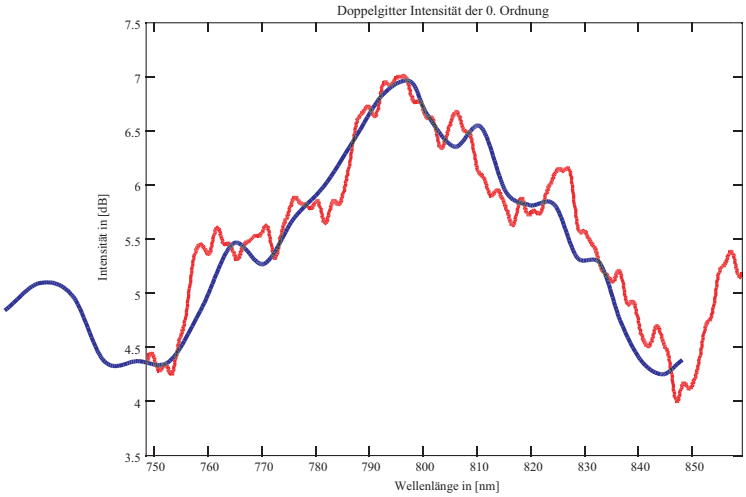


Fig. 1: Power spectrum of the investigated Talbot interferometer. Fidgetted curve represents calculated values, the smooth curve is measured.

[1] H. Knuppertz, J. Jahns, "Temporal impulse response of the Talbot interferometer", this Ann. Rep.

[2] J. Jahns, A. W. Lohmann, "Temporal filtering by double diffraction", *Appl. Opt.* **43** (2004) 4339–4344.

[3] J. Jahns, H. Knuppertz, A. W. Lohmann, "Montgomery self-imaging using computer-generated diffractive optical elements" *Opt. Comm.* **225** (2003) 13–17.

Propagation of an ultra short pulse through a grating

H. Knuppertz

We investigated how an ultra short pulse with a duration of only a few periods of the carrier light wave is diffracted by a phase grating. Before the advent of optical femtosecond pulse sources optical experiments usually were performed with stationary wave fields with no significant temporal changing. Meanwhile mode locked lasers supply ultra short pulses with reasonable prices and intrigues the research of the features and possible applications [1]. For signal processing ultra short pulses might provide higher transfer capacity and enable advanced multiplexing schemes. For a basic 2D-simulation we first define the phase function for a grating with $2N+1$ periods p:

$$\phi(x) = \frac{1}{2} \sum_{n=-N}^{N} \mathrm{rect}\left(\frac{x - np - p/2}{p/2}\right) \tag{1}$$

A perpendicular incident Gaussian pulse wave $\mathrm{gauss}(z) = \exp(-\pi z^2/\Delta z^2) \cdot \exp(2i\pi z/\lambda_0)$ is diffracted by the grating that is assumed to be optically thin and located at z_0. A snapshot of the pulse passing the grating can be composed of a part not yet diffracted and a preceding part already diffracted and phase shifted by the grating with $f(x,y) = \mathrm{gauss}(z)\exp(2i\pi\phi(x))$. The diffracted part then is composed of elementary spherical waves that originate at the grating (Huygen's principle). These spherical waves determine additional phase shift and attenuation for a certain point of detection. Using the scalar Fresnel-Kirchhoff diffraction integral and the Heavyside function $\sigma(x)$ the observed wave field at a certain location x, z and time t is

$$\begin{aligned} u(x,z,t) &= [1-\sigma(z-z_0)]\mathrm{gauss}(z-ct) \\ &+ \sigma(z-z_0)\int_{-Np}^{Np} \left\{ \begin{array}{c} f\left(x_0, z_0 + \sqrt{(x-x_0)^2+(z-z_0)^2} - ct\right) \\ \exp\left[2i\pi \frac{\sqrt{(x-x_0)^2+(z-z_0)^2}}{\lambda_0}\right] \\ \frac{(z-z_0)}{(x-x_0)^2+(z-z_0)^2} \end{array} \right\} dx_0 \end{aligned} \tag{2}$$

Fig. 1 presents a 3D-intensity plot with a Gaussian pulse that just passes for one half the grating. The shape resembles a short water wave that passes some bridge piers.

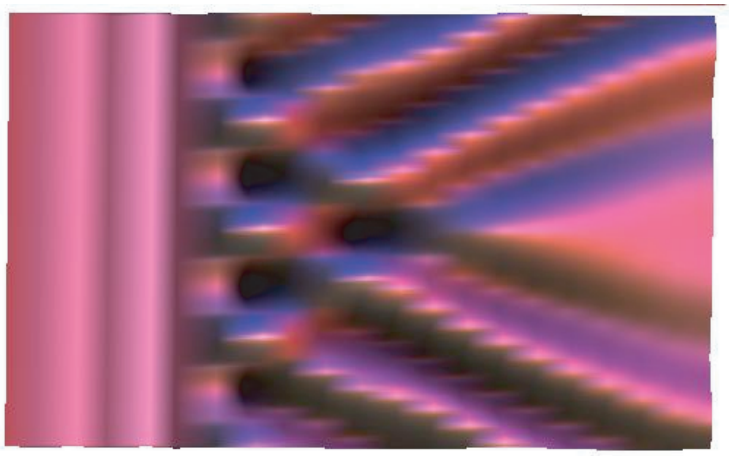


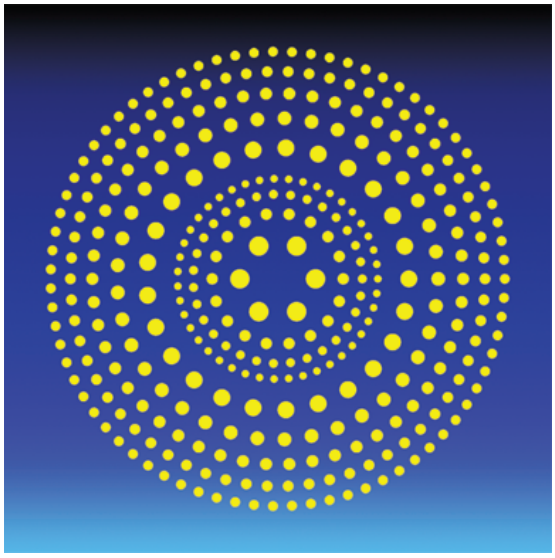
Fig. 1: Simulation of an ultrashort pulse propagating through a phase grating. The pulse consists of then waves, the grating period is equal to the wavelength. The center of the pulse is just passing the grating.

[1] H. Knuppertz, J. Jahns, "Temporal impulse response of the Talbot interferometer", this Ann. Rep.

Equivalent pupil functions for quasi-circular-symmetric photon sieves

Qing Cao and Jürgen Jahns

A few years ago, Kipp et al. proposed a novel diffractive optical element called a photon sieve [1] for the focusing and imaging of soft x-rays and EUV radiations. A photon sieve is composed of a great number of pinholes properly distributed over the Fresnel zones. Following the initial Nature paper, we quickly established the first analytical model [2, 3] for photon sieves. So far, photon sieves have been suggested for various new applications. For examples, Artzner et al. suggested the application as EUV telescope for solar orbiter [4]; Menon et al. suggested the application for EUV lithography [5]; Quite recently, Andersen even suggested the application as ultra-large space telescope [6] with ultra-high resolution. This suggested ultra-large space telescope is much larger than the famous Hubble space telescope and have the potential to see much deeper into the universe.
Recently, we established the equivalent pupil function theory for a general modified Fresnel zone plate [7]. Here, we show that the equivalent pupil function theory for a quasi-circular-symmetric photon sieve can also be established.
As shown in the following figure, for a quasi-circular-symmetric photon sieve, the pinholes can be divided into many ring-shape sub-regions. In each ring-shape sub-region, there exists a underlying circle and the pinholes are uniformly distributed along this circle. It can be proven that the diffracted field of a sub-region is approximately equal to the diffracted field of a certain open ring, provided that the number of pinholes in each sub-regions is large. Based on this property and the work of Reference [7], we have established the equivalent pupil theory for a quasi-circular symmetric photon sieve. The details will be published elsewhere.



We would like to thank Tina S. Heldt for her help in generating the art figure of a quasi-circular symmetric photon sieve.

[1] L. Kipp et al., Nature (London) **414** (2001) 184–188

[2] Q. Cao and J. Jahns, J. Opt. Soc. Am. A **19** (2002) 2387

[3] Q. Cao and J. Jahns, J. Opt. Soc. Am. A **20** (2003) 1005

[4] G. E. Artzner et al., Proc. SPIE **4853** (2003) 158

[5] R. Menon et al., J. Opt. Soc. Am. A **22** (2005) 342

[6] G. Andersen, Opt. Lett. 30 (2005) **2976**

[7] Q. Cao and J. Jahns, J. Opt. Soc. Am. A **21** (2004) 561

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Planar-integrated optical interconnects with replicated refractive micro-lenses

R. Heming, L.-C. Wittig*, E.-B. Kley*, J. Jahns, M. Gruber

Planar-integrated free-space optics (PIFSO) is a system concept [1] that has the potential to meet the technological and performance requirements of the next-generation short-range optical interconnects. To improve the coupling efficiency of existing demonstrator modules that were solely based on stepped surface-relief diffractive optical elements we investigate the additional integration of elements with continuous profiles for a fiber-PIFSO-fiber interconnect test module as shown in Fig. 1.

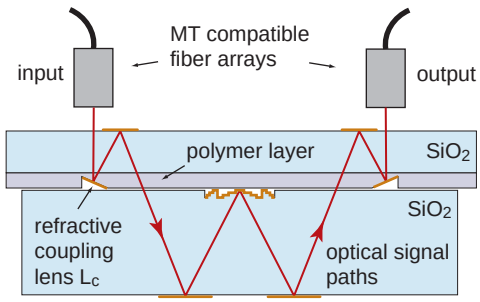

Fig. 1: Scheme of the interconnect module.

Multilevel and continuous-profile ('refractive') components were realized on separate substrates using binary lithography plus reactive ion etching and analog lithography based on HEBS-glass masks plus a system replication into a thin layer of polymer (ORMOCER) on a SiO_2 carrier [2], respectively. Fig. 2a shows the finished lower substrate with the multilevel elements, part of a polymer lens array is depicted in the REM image of Fig. 2b; the quantitative evaluation of the continuous surface profiles with a white-light interferometer (cf. Fig. 2b) produced an excellent agreement with the design data.

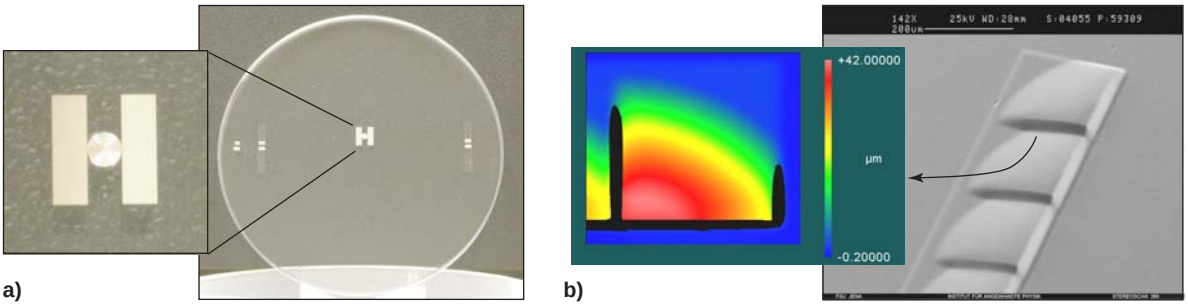

Fig. 2: Lower part of the experimental module with stepped elements (a), REM image and white-light interferogram of (off-axis) polymer lenses on the upper part of the experiemtal module (b).

The experimental evaluation of the interconnect module was carried out with the setup of Fig. 3. Optical signals ($\lambda = 850\,\mathrm{nm}$) were coupled in via single-mode fiber arrays that were mounted on micro-positioning stages. As targets multi-mode fiber arrays were used. First, the signal spots generated by the PIFSO system were recorded and found to fall on their designed positions. Then, fiber-to-fiber coupling efficiencies were measured. A typical value of -4.4 dB was obtained which is an improvement of a factor of 3 compared to similar systems with stepped components only. The additional technological effort of our approach may therefore be justified in certain practical applications.

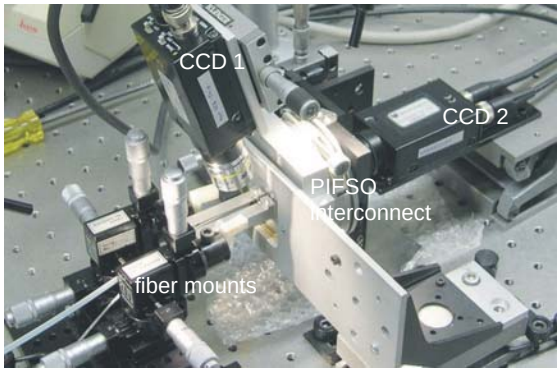

Fig. 3: Experimmental setup.

[1] M. Gruber, J. Jahns, in *Microoptics – from technology to applications*, Springer (2004), 225-252.

[2] P. Dannberg L. Erdmann, R. Bierbaum, A. Krehl, A. Bruer, E. Kley, *Microsys. Technol.* **6** (1999) 41.

∗ Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena, Germany

Optical trapping of atoms in the ring focus of a donut-type diffractive lens

M. Gruber, J. Jahns, M. Volk*, G. Birkl*, T. Müther*, J. Nes*, A. Gehrmann*, W. Ertmer*

Optical traps are based on light distributions with a strong intensity gradient of such a form that the arising electrical dipole forces are always directed towards the trap which prevents micro-particles from escaping it. This enables non-contact manipulation of such particles, which is an interesting feature for many applications especially in life sciences and particle physics. Here we report about the trapping of ultra-cold ^{87}Rb atoms in the ring focus of a donut-shaped lens (see Fig. 1) as a first step to construct a micro-interferometer for coherent matter waves [1].

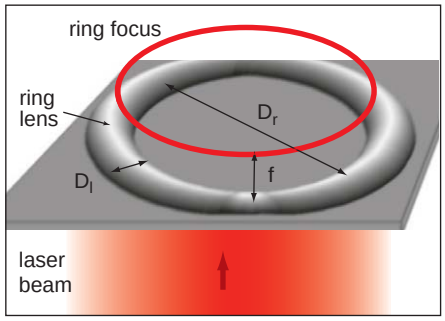

Fig. 1: Schematic drawing of our setup to generate a ring-shaped optical trap.

The donut lens, which can be interpreted as a cylindrical lens that has been 'bent' into ring shape, was realized as a surface-relief diffractive optical element with 8 discrete phase levels (Fig. 2a); fundamental design parameters were $D_r = 1.5\,\mathrm{mm}$, $D_l = 500\,\mu\mathrm{m}$, and $f = 650\,\mu\mathrm{m}$. Upon illumination with a uniform plane wave at $\lambda = 780\,\mathrm{nm}$ the lens generated a ring focus part of which is depicted in Fig. 2b. The radial intensity scan of Fig. 2c clearly shows the asymmetry of the observable side lobe intensities which is a consequence of the above-mentioned 'bending' of a (symmetric) cylindrical lens.

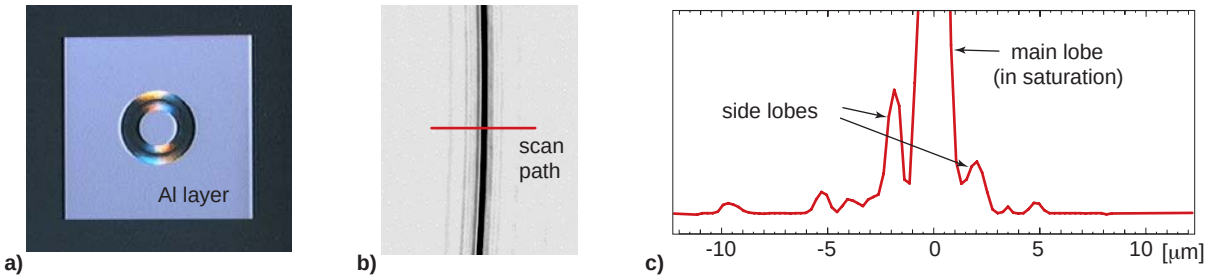

Fig. 2: Diffractive donut lens with a structured Al layer as aperture stop (a), inverted grey-scale image of part of the generated ring focus (b), and intensity scan along the indicated radial scan path (c).

A magneto-optical trap (MOT) was used to keep the atom cloud initially in place and to lower its temperature down to a few μK by optical laser Doppler cooling. The cloud was then released from the magnetic trap so that it could spread around the ring focus due to gravitational and diffusion forces. Fig. 3 shows four snapshots of this process.

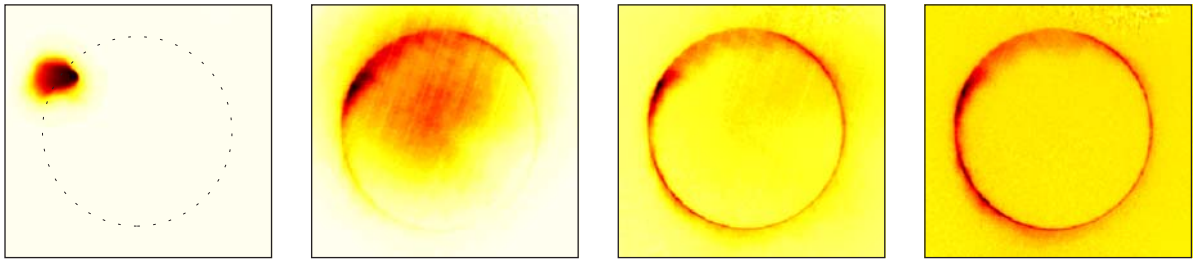

Fig. 3: Absorption images showing the loading of the optical trap and the spreading of the atom cloud.

[1] T. Müther, J. Nes, A. Gehrmann, M. Volk, W. Ertmer, G. Birkl, M. Gruber, J. Jahns, "Atomic quantum systems in optical micro-structures", *Journal of Physics: Conference Series* **19** (2005) 97.

∗ Institut für Quantenoptik, Universität Hannover, Welfengaten 1, 30167 Hannover, Germany.

Generation of optical vortex beams with diffractive optical elements

Matthias Gruber

A light beam contains an optical vortex if the light distribution $u(r,\theta)$ in a plane orthogonal to the z-axis of propagation can be expressed as a product

$$u(r,\theta) \;=\; \exp\Big[-in(\theta-\theta_0)\Big]\cdot f(r) \qquad (1)$$

with r, θ as polar coordinates and n as a non-zero integer that causes a characteristic phase singularity at the origin. This feature is essentially preserved upon propagation, there is only a z-dependent increase of θ_0 that leads to a helical phase structure of the beam. As a consequence, optical vortex beams carry angular momentum and have a strong intensity gradient with zero intensity at $r = 0$ for all z-values ('hollow beams'). This makes them interesting tools for trapping, rotating, or exerting torque to micro-particles.

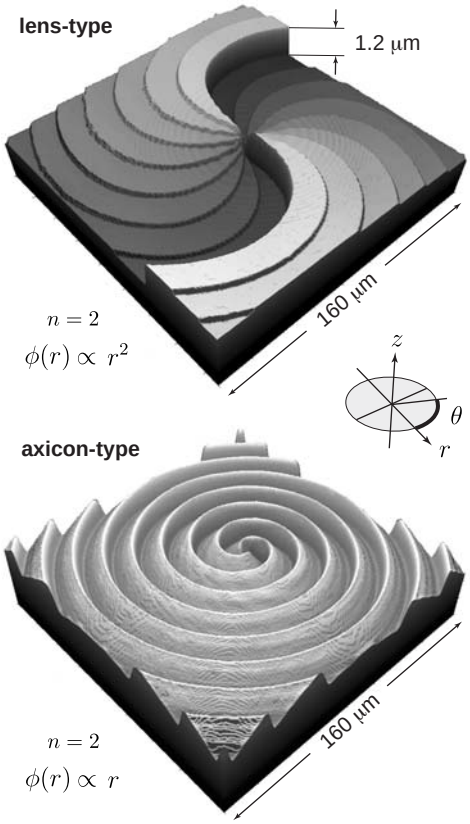

Fig. 1: Surface profiles of two 8-phase-level vortex beam generator DOEs (recorded with a confocal microscope).

There is design freedom concerning the topological charge n and the radial function $f(r)$. We focus on pure phase functions $f(r) = \exp\left[-i\phi(r)\right]$ such that $u(r,\theta)$ can conveniently be implemented by means of a surface-relief diffractive optical element (DOE); filtering a uniform plane wave with it generates the hollow beam. Mathematically, the effect of n and $\phi(r)$ on the evolving light distribution $u(r,\theta,z)$ can be described by Kirchhoff's diffraction integral which can be written in a form

$$u(r,\theta,z) \;\propto\; \exp\Big[-in(\theta-\theta_0)\Big]\cdot\int J_n(C_1 r)\,\exp\Big[-i\Big(\phi(r)-C_2 r^2/2z\Big)\Big]\,rdr \qquad (2)$$

with $J_n(x)$ as n-th order Bessel function and C_1, C_2 as constants. Eq. (2) reveals that the beam divergence is largely determined by $\phi(r)$ and that there are similarities with conventional vortex-free beams, for example, parabolic phase profiles lead to a lens-like focusing behavior whereas linear axicon-type profiles generate quasi-diffraction-free beams. Eq. (2) can also explain the effect that the observable diameter of the dark spot in the center of a vortex beam increases with n: Bessel functions behave like power functions x^n near $x = 0$. Both features were demonstrated experimentally at $\lambda = 632.8\,\text{nm}$ with the two DOEs the center parts of which are depicted in Fig. 1 and similar ones. Fig. 2 shows some results.

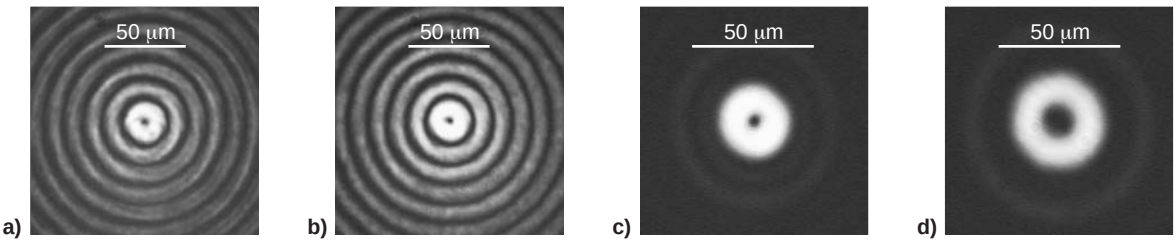

Fig. 2: Quasi-identical intensity profiles behind an axicon-type $n = 1$ vortex beam generator at distances $z = 4\,\text{mm}$ (a) and $z = 7\,\text{mm}$ (b); different observable dark spot diameters in the focal plane of two lens-type vortex beam generators with equal $\phi(r)$ but $n = 1$ (c) and $n = 2$ (d), respectively.

Low-cost amplitude-only diffractive optical elements for optics education

Matthias Gruber

Experiments with various kinds of diffraction gratings belong to the standard repertoire of a lab course on optics, especially on Fourier optics. Often, optical 4-f-setups are used to demonstrate basic information processing tasks like matched filtering. Ideally, students should have the opportunity to design a specific filter function, have it realized as a computer-generated hologram (CGH), and evaluate it experimentally. There is thus a need for low-cost methods to fabricate CGHs of at least moderate quality for optics education.

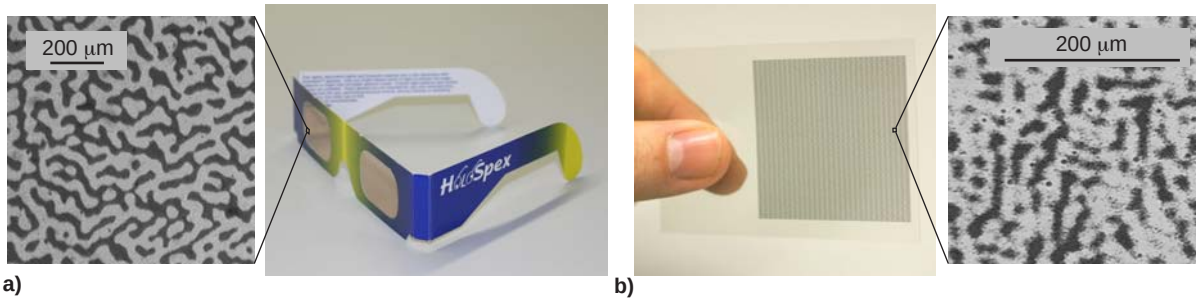

Fig. 1: Practical realizations of low-cost binary amplitude-only CHGs: Commercial product "HoloSpex" [1] (a) and sample of a synthetic foil that has been exposed with a high-resolution imagesetter.

Commercial products involving low-cost CGHs like the spectacles of Fig. 1a [1] that sell for a few Dollars a piece and produce nice visual effects in combination with point-like light sources (cf. Fig. 2a) show that this task can be solved. A closer inspection of the spectacle-lenses reveals that they consist of binary amplitude-only CHGs on a thin sheet of synthetic material. The features of the holographic gratings are comparatively large although their edges are very sharp which suggests that they have been replicated from a high-quality lithographic mask.

To avoid the expenses for a mask a direct writing approach is proposed here. It is based on the service of a commercial offset print shop. Their high-resolution imagesetters usually have a resolution of 3600 dpi which allows one to produce binary amplitude-only CHGs on plastic foil at the cost of typically a few tens of Euros per A3-sized sheet. Fig. 1b shows a sample that was cut out of such a sheet; its holographic features are even smaller than those of the "HoloSpex" CGH although their edges are less well-defined. Nevertheless, the sample produced a Fraunhofer diffraction pattern of surprisingly good quality as one can judge from Fig. 2b; it even appears less granular than the one of the "HoloSpex" CGH. As usual for an amplitude-type CGH the diffraction pattern is point-symmetric about the zeroth order.

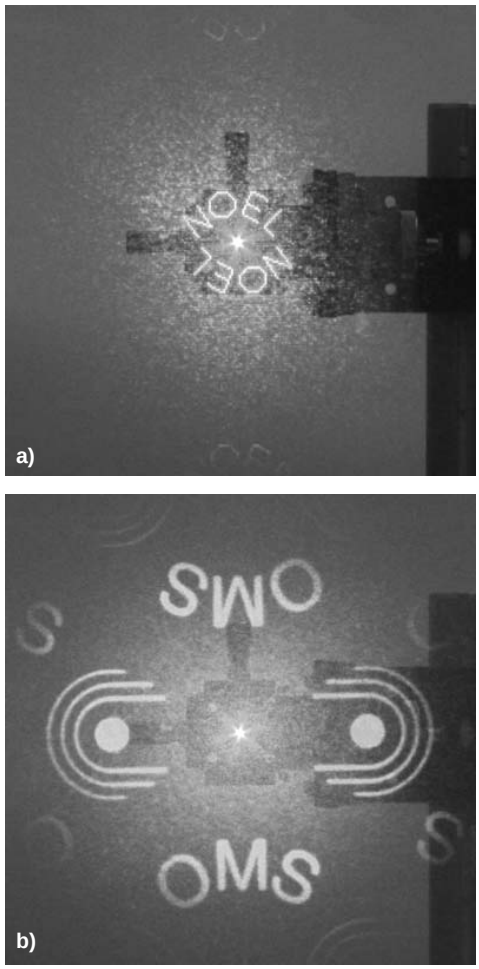

Fig. 2: Diffraction patterns of the CGHs of Fig. 1 (recorded with a digital camera focused to a laser-illuminated pinhole and with the CGH in front of the camera lens).

[1] see the URL "www.holospex.com/index.html".

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Dipl.-Inform. Bernd Winnige	-1108

Modelling and Observation of Semi-Batch Reactors

Marcus Nohr, Veit Hagenmeyer* and Michael Gerke

Semi-batch reactors are widespread in chemical plants for the synthesis of various products. Process observation and control is hard because of a multitude of different distributed parameters and flow/transfer rates. Academic interest has been focused mostly on modelling of small scale semi-batch reactors, where certain assumptions and restrictions apply. On the other hand, in industry now these reactors become more extended, so that academic models are no longer valid here and fail.

It is due to this reason, that research has been carried out to start describing those realistic semi-batch reactors by valid models in order to predict all state variables with an observer, which serves as input for process control. We considered two different types of cooling systems, namely those where the coolant temperature at the system input serves as regulating variable, and those where the coolant flow rate is used for this purpose.

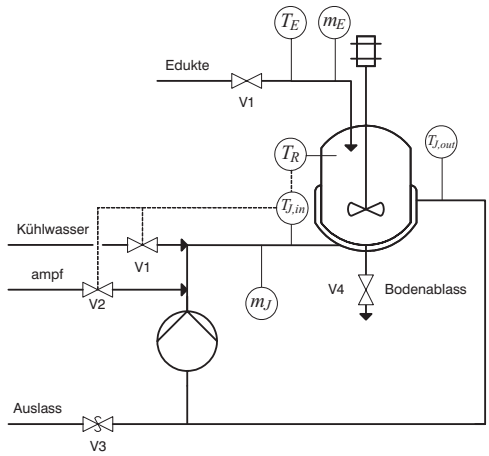


Figure 1: Coolant temperature control type

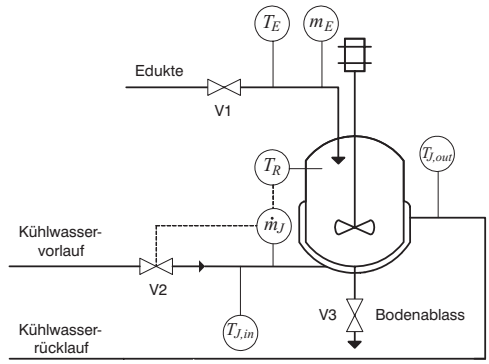


Figure 2: Coolant flow rate control type

For the mathematical description of both types of cooling systems discretizing approximation methods are used: the methods of orthogonal collocation and of finite differences. Different variants are analyzed and evaluated with respect to the underlying process. A process modell is chosen to derive a valid observer based on Extended Kalman Filters. The observer's estimation of time behavior is very satisfying and realistic for large scale semi-batch reactors.

This new modelling approach should turn out to be of high practical relevance, both in industry and in science.

[1] *M. Nohr:*
Zur Modellierung des Kühlsystems
für die Beobachtung von Semi-Batch-Reaktoren
im Produktionsmaßstab
Diploma Thesis (in German), Hagen 2005

*Dr. Veit Hagenmeyer is with BASF AG, Ludwigshafen, Germany

Internal Sensorics for a Flying Robot

C. Föcking, I. Masár and M. Gerke

Our intention to build a flying robotic system based on airship technologies is currently divided into two workpackages:

- constructive optimization of the airship's thrust system, its fins and gondola, with respect to high manoevrability in restricted in-door environments,
- and integration of an efficient control system using internal sensorics of the blimp.

With the optimization of the airship nearly finished, our main focus is now on stabilization and control of the autonomous system under the influence of disturbances (e.g. airflow). Therefore, the blimp's gondola is not only equipped with DSPs and their peripherals, but with accelerometers (Analog Devices XL series) and gyroscopes (Analog Devices XRS series) on a single chip. In-flight tests and performance analysis show sufficient data resolution to provide the necessary information for the blimp controllers to handle disturbances caused by airflow and even to build a rudimentary dead-reckoning for small positional changes.

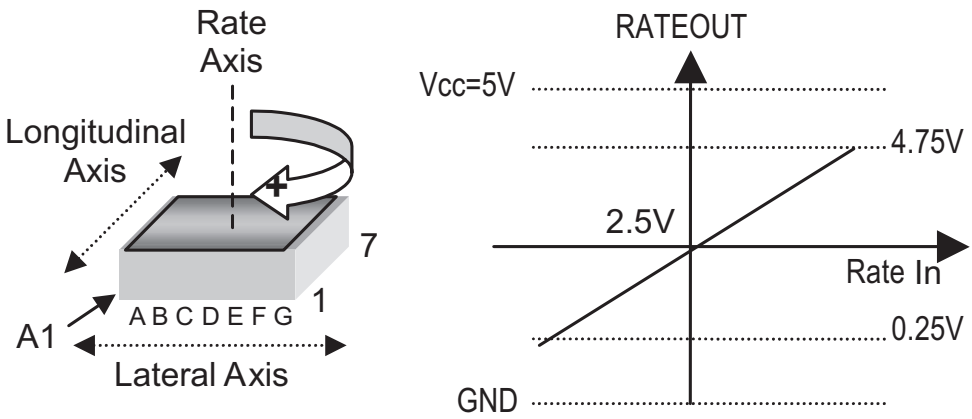


Figure 1: Gyroscopic measurement of rotational changes

First experiments are carried out with Fuzzy controllers in all linear axes (X, Y, Z) and rotational axes (Roll, Pitch, Yaw) of the autonomous airship.

[1] *Michael Gerke:*
Aufbau und Regelung eines Roboter-Luftschiffes
(in German),
Mechatronik 2005, Innovative Produktentwicklung
6. Tagung der VDI-EKV und der VDI/VDE-GMA
Wiesloch bei Heidelberg, Juni 2005

Localization of Vehicle Passengers with a State Observer

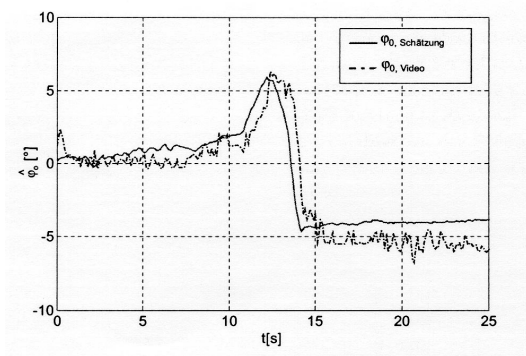
Reiner Marchthaler, Helmut Hoyer

To protect vehicle passengers in the course of an accident, various safety systems have been integrated into the car. Serious injuries can be avoided by an efficient cooperation of safety restraint systems such as airbags and automatic safety belts. Today's cars include a number of airbags located at different positions (front, door, thorax, head, knees) and belt tensioners. These restraint systems are activated by a central controller unit based on the input of electronic sensors. These sensors not only detect an accident, but also classify the type of crash (frontal, side, roll-over). The safety restraint controller decides within $\approx\ 1\ ms$, which airbags have to be ignited. The whole inflating procedure needs about $12\ -\ 18\ ms$.

One important aspect that should be considered in future safety restraint systems is the actual position of the car passenger on the seat, because this can influence the airbag inflating strategy drastically. Sensorics for detecting a mass distribution on the passenger seat are already available (integrated into the seat cushion or seat bolts); their output signals have to be calculated with the help of a valid mathematical passenger model.

A satisfying model has been derived here based on a dynamical analysis of the passenger's body and head motion behavior. From the actual sensor input, the current position of the passenger can be estimated with a state observer. Parameter estimation methods are used to up-date the passenger model and to identify unknown system states and parameters. Linear and non-linear Kalman filters are used for this purpose.

(a) Passenger in long curve



(b) Estimation vs. Video data

Figure 1: State observer's estimation vs. Video measurement of Passenger side angle φ

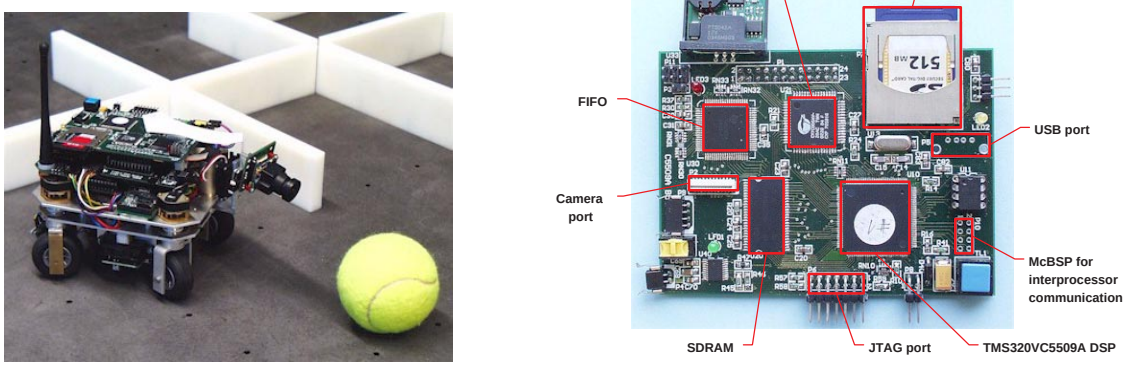
[1] *R. Marchthaler:*
Verfahren zur Lokalisierung eines Fahrzeuginsassen
mit Hilfe eines Zustandsbeobachters
Ph.D. Thesis (in German), Hagen 2004

[2] *M. Pfeil*
Parameterbestimmung eines Insassenmodells für
Rückhaltesysteme mit estimationstheoretischen Methoden
Diploma Thesis (in German), Stuttgart 2004

Visual Servoing of Mobile Robots

Ivan Masár

The local navigation of a mobile robot in unknown environments requires various sensors for detecting and avoiding obstacles, world mapping, etc. A visual system used for these tasks can be a good solution for small robots with restricted resources and space. Therefore, we decided to design a visual system for use on our small-size experimental mobile robots. The developed visual system is based on the high-performance, low-power TMS320VC5509A DSP. We chose this DSP because of its performance, low power consumption as well as useful on-chip peripherals like MM/SD card interface and USB2.0 port. As the image source, a miniature color camera module with CCD sensor is used. Optionally, two cameras can be used on the robot for stereovision. The camera provides the digital image data on its 8-bit/16-bit port according to YUV format. Picture data are buffered into the FIFO memory and then read by DSP for further processing. During experiments, individual pictures or their sequences can be saved on MM/SD memory card or USB memory stick and evaluated consequently. The camera module is mounted on a small mounting head, which can move in two directions. The camera motion is controlled by a TMS320F2812 DSP, which in addition controls the robot motion. The position commands and other data between the processors are exchanged through the McBSP-port or dual-port memory. The components of the visual system are shown in Fig. 1 and the designed image processing board is in Fig. 2.



(a) Mobile robot with the visual system

(b) Image processing board

Figure 1: Developed visual system

Various object-tracking algorithms were realised with the presented visual system. These experiments show, that the designed system is suitable for integration on our mobile robots and its performance should be sufficient for the proposed visual servoing. In our current research, we focus on the implementation of visual servoing for all of our mobile systems (ground and flying robots). Using the developed vision system, the flying robot is able to recognize any ground robots and it could help them during navigation. This airborne system could warn them in advance if it recognizes unavoidable obstacles or impasses situated on their preplanned trajectories and thereby it helps to save their power resources. The ground robots can use their on-board vision system for collision avoidance and for object recognition.

[1] F.A.A.K. mobile robot project: http://prt.fernuni-hagen.de/pro/faak/

Path-Planning and Motion Control of a Nonholonomic Mobile Robot Using Planar Curve Theory

Frank Walter, Ivan Masár

The experimental robot F.A.A.K., constructed in our research group, is a non-holonomic experimental mobile robot with a specific kinematic structure. All its wheels are steered and thereby, the robot is able to execute various motion types that are otherwise not executable by (usual car-like) mobile robots.
However, there is still a lack of methods generally applicable to modelling and control of such types of wheeled mobile robots. The main problem is the computation of the inverse kinematic model of the robot, which is required for open-loop motion control. The absence of an inverse kinematic model follows from the singularity of the wheel inverse Jacobian matrix. Therefore, we investigated the applicability of planar curve theory for robot path-planning and motion control. The basic idea is the approximation of the robot trajectory by an analytically defined planar curve and the robot motion by kinematics of a rigid body. Then, using the trajectory equation and its differentiations, all the required speed and acceleration profiles of the robot steering axles and wheels can be computed by kinematic transformations. Because of easy-to-use, smooth first and second differentiation and definable boundary conditions, a cubic spline was choosen as the path approximating curve. However, the robot path is usually too complicated to be approximated by a single spline. Therefore, we developed a path-planning algorithm, which uses so-called partial splines. The partial spline is the smallest trajectory element, which is passed through by the robot in one trajectory-following cycle. At the end of the partial spline, the robot checks its position towards the desired path and computes the next trajectory element. The partial splines are designed with respect to robot kinematic and dynamic constraints like the maximal angular speeds and angles of the wheels and steering axles. Moreover, the global path-planning system is designed using the partial splines. With this gradient-based optimizing method, the complete robot path can be assembled from partial splines accordingly to the constraints resulting from the robot's non-holonomic bindings.
The simulations show the good performance of the robot open-loop motion control. However, the robot dynamics must be considered by the trajectory generation for further improvement of the path following. Moreover, the global path-planning must be extendend with obstacle avoidance realized by local modification of the robot trajectory (Figure 1).

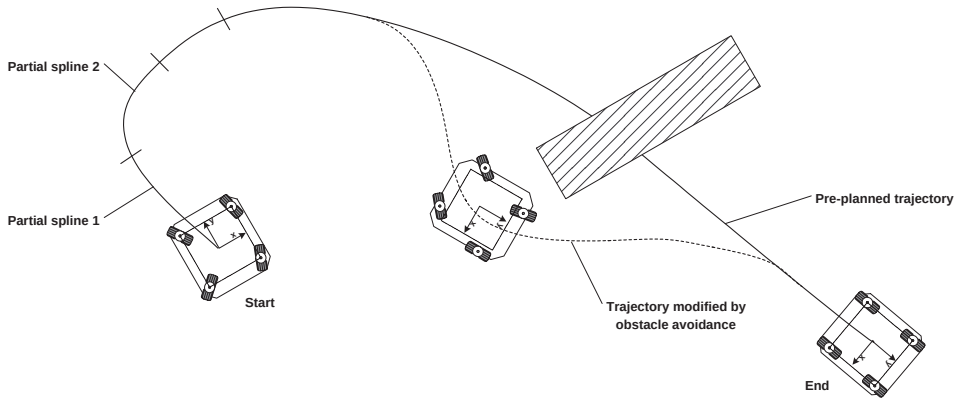


Figure 1: Path-planning using partial splines

[1] F. Walter: Bestimmung von Bewegungstrajektorien zur Steuerung eines mobilen Roboters auf der Grundlage der Theorie ebener Kurven
Diploma thesis, Hagen, November 2005 (in German)

Developing of an Integrated Environment for the Modelling, Simulation, and Rapid Design of Control Algorithms for Mobile Robots

Ivan Masár

At present, we are working on a distributed multirobot system with several cooperating ground and aerial mobile robots. Such a heterogeneous system with various kinematic and aerostatic subsystems can perform complex tasks in extremely demanding environments. However, the process of developing, implementing, and fine-tuning control strategies for this type of complex multirobot system is extremely time-consuming. Therefore, we used the MATLAB™ and Simulink™ product families to design an integrated environment for modelling, simulating, rapidly prototyping algorithms and hardware-in-the-loop (HIL) testing.

The first step in designing a control algorithm is creating a model of the controlled system and then validating it with simulations. To do this, we designed a Simulink library containing the robot and sensor models. However, simple simulations of the robot model are not sufficient to simulate the autonomous behavior of a mobile robot (or a multirobot system), since such simulations do not consider the robot's interactions with its environment or with other robots. For this reason, we designed the 'MapGen' tool, which enabled us to design artificial worlds so that we could simulate the robots in various environments characterized by different obstacles (Figure 1).

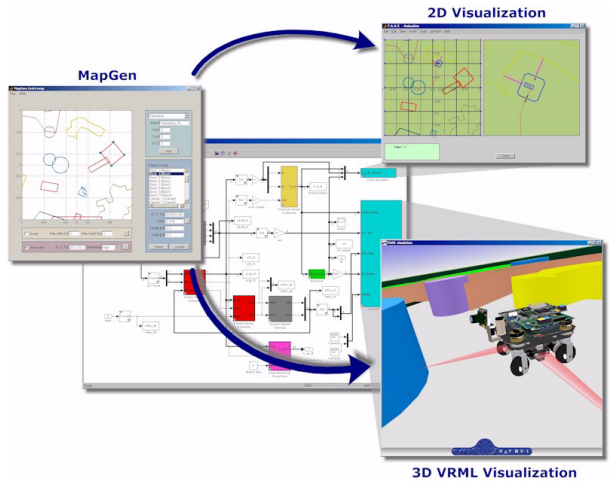


Figure 1: Simulation of the robot

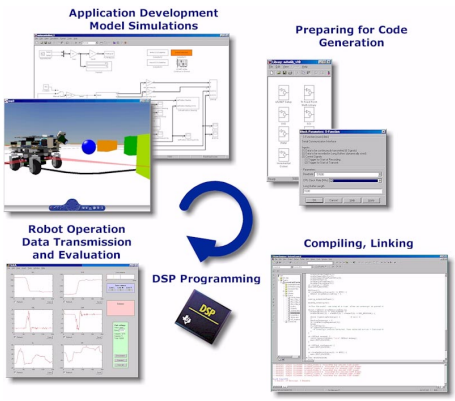


Figure 2: Rapid design of the control algorithms

The next step in designing control algorithms is to implement and test them in the DSP using HIL simulations. Instead of hand-coding of robot algorithms, we adapted the Embedded Target for TI C2000 DSP to generate code automatically and deploy it onto the robot's processor. After the generated program is transferred to the DSP, the robot can execute the tested algorithm. To evaluate the data from the robot, we designed a communication mode between MATLAB™ and the robot that uses the serial interface via a serial cable or using radio modules (Figure 2).

[1] I. Masár, R. Gabler: An Integrated Environment for the Modelling, Simulation, and Rapid Design of Control Algorithms for Mobile Robots,
MATLAB Digest, September 2005,
http://www.mathworks.com/company/newsletters/digest/2005/sept/mobile_robots.html

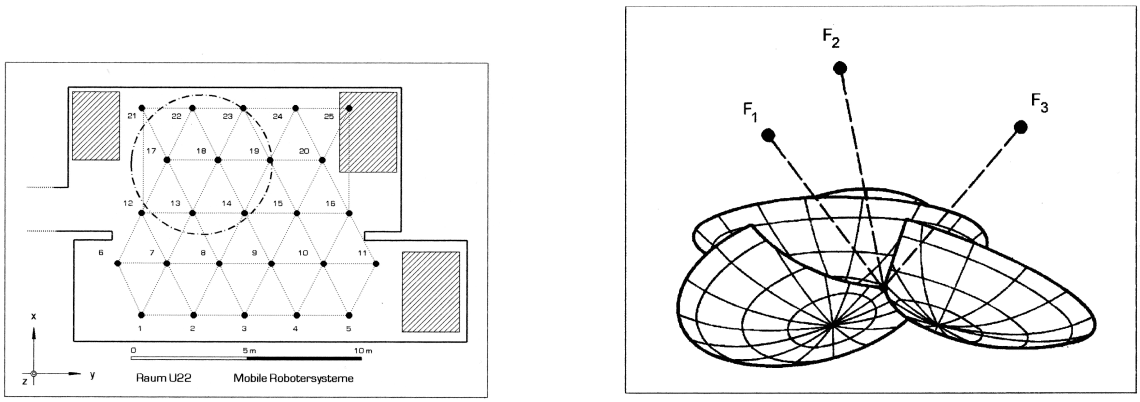
[2] F.A.A.K. mobile robot project: http://prt.fernuni-hagen.de/pro/faak/

An Ultrasonic Localization System for 3D-Targets

Hans-Günter Schmidt, Michael Gerke

One of the major problems in mobile robotics is the precise localization of moving targets with respect to absolute position and orientation in their environment. For mobile ground robots this 2D-problem is usually solved with the help of landmarks and beacons, because 'dead reckoning' from a known start position with internal on-board sensorics leads to cumulating errors. The problem becomes even more complex, if free-flying robots in three-dimensional (3D) space are considered.

A new localization system has been developed in our research group based on a stationary ultrasonic receiver matrix, that calculates the mobile robots' absolute position from a signal emitted by an ultrasonic sender unit mounted on top of the moving system. Based on the sonic distance between the transmitter and each receiver unit, geodesic considerations lead to an exact localization.



(a) Receiver matrix in robotic lab (b) Geodetical Approach for localization

Figure 1: The FernUni Localization system

The calculation of absolute positions can be carried out in realtime, so this ultrasonic localization system can be integrated into closed-loop control of the mobile system. Because of many disturbing time-variant influences during measurement (temperature gradient, air pressure, noise, etc.), the system includes strategies for error recognition and compensation.

[1] *H.G. Schmidt:*
Ein fehlertolerierendes Ultraschall-
3D-Lokalisationssystem zur Detektion
von Trajektorien beweglicher Objekte
Ph.D. Thesis (in German), Hagen 2005

[2] *F. Figueroa, E. Doussis and E.Barbieri*
Ultrasonic Ranging System for 3D Tracking
of a Moving Target
92-WA/DSC-3, Proceedings of the Annual Winter Meeting
AMSE, Anaheim, CA, November 1992

Speech Control and Speech Output for a Pioneer 3-AT Mobile Robot

Andreas Bischoff

For applications in service robotics, voice control via speech recognition is a highly demanded technology. We have added a speech recognition application to an autonomous Pioneer 3-AT mobile robot to realize local and remote speech control features. We have adapted the commercial IBM Visualvoice Software[1], which is available for Linux and Windows, to communicate with the robots application programmers interface (API). The robot API consists out of two parts, an API for simple movement commands (ARIA) and an API for high level autonomous robot behavior (Saphira). Together with a Linux or Windows based SIP Softphone (SIP, **S**ession **I**nitiation **P**rotocol, RFC 3261)[2] the robot can be controlled by speech over a wired phone line as well as by mobile phones. In service robotic applications, this feature can be used to instruct the mobile robot via phone for new tasks. To monitor the state of the local operating system and sensor information the pioneer robot is equipped with a wireless LAN (WLAN) adapter. But in case of loss of WLAN connection or system shutdown triggered by low power batteries no connection is available to monitor these events. No internal display is available in mobile usage. It is inconvenient to connect the onboard PC to an external display and input devices. Speech output is an alternative way to monitor these events. We have realized robot speech output by using the 'mbrola' speech synthesizer[3] software which uses a list of phonemes as input. With 'Txt2pho'[4], a german text to speech (TTS) front-end for 'mbrola', we are able to generate phonemes for speech output from text based system event messages. We are using these TTS techniques to generate audio based teaching material (mp3, wma and podcast) automatically from text material, too[5].

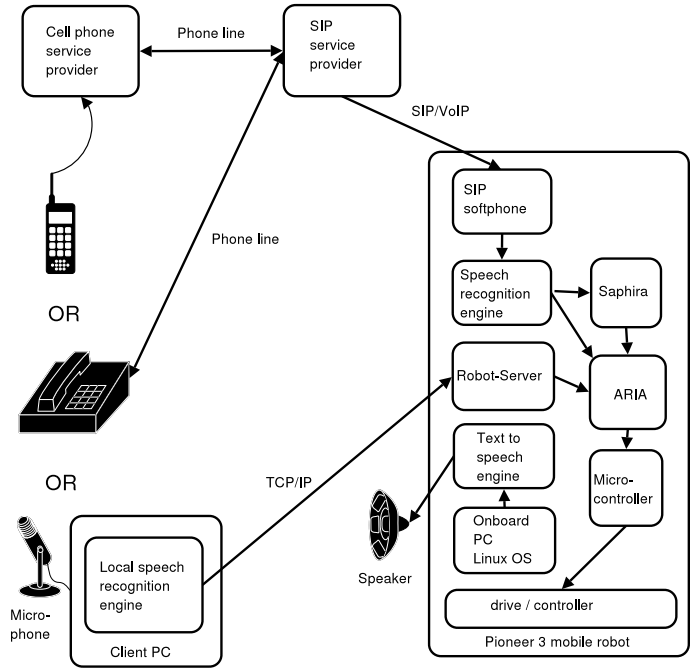


Figure 1: Communication structure for speech control of a Pioneer 3-AT robot

[1] http://www-306.ibm.com/software/info1/websphere/index.jsp?tab=products/mobilespeech

[2] http://www.ietf.org/rfc/rfc3261.txt

[3] http://tcts.fpms.ac.be/synthesis/mbrola.html

[4] http://www.ikp.uni-bonn.de/dt/forsch/phonetik/hadifix/HADIFIXforMBROLA.html

[5] Reactive robot programming, M.Sc. courseware 21605
http://prt.fernuni-hagen.de/lehre/PRAKTIKUM/KURZ/roboter.html

[6] http://prt.fernuni-hagen.de/pro/pioneer/

Ubiquitous Computing and Streaming Technologies for Synchronous m-Learning - A Mobile Environment for Remote Laboratories

Andreas Bischoff

Providing students with html, pdf or WAP static text based learning material for m-learning is state of the art. Solutions like PDF viewers and browsers like PocketIE, Opera, Netfront and Minimo are able to render text in a useful way on the limited screen sizes of todays PDA and smartphones. To support active, non static, multimedia, Virtual Reality or streaming content we have adapted our web based remote laboratory environments to mobile devices like PDAs and smartphones. Today's PDAs have displays up to 640x480 pixels resolution, which is enough to control our experiments. The modified client Java applets are running on a 'Personaljava' virtual machine. 'Personaljava' is a Java runtime environment for mobile devices with limited resources.

Figure 1: Pioneer AT-3 mobile robot remotely controlled by a Windows CE NET smartphone (bSquare Maui)

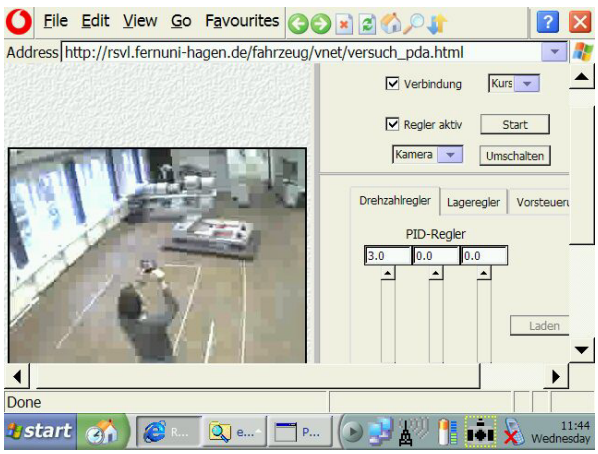


Figure 2: Screenshot of a remote experiment rendered by PocketIE on a bSquare Smartphone, 640x480 pixels (Control of a mobile robot platform)

Different to J2ME, the 'Personaljava' implementation provides the full AWT (Abstract Window Toolkit) API. Implementations of Personaljava are available for Windows CE, Linux, Palm and Symbian OS based PDA and mobile phone platforms. Our favorite streaming solution (SUNs Java Media Framework JMF) is not available on mobile platforms. As an alternative for mobile users we provide a MPEG4 based video stream, generated by the Linux based ffmpeg/ffserver [1] solution. As container we are using the Microsoft ASF streaming format. ASF was natively supported by PocketPC variants (PocketPC 2002, Windows Mobile 2003, Windows CE NET). For Linux based PDAs the VideoLan player is an alternative. On Windows CE based PDAs and smartphones the ASF/MPEG4 stream is embedded to a webpage with an ActiveX control.

[1] http://ffmpeg.sourceforge.net/

[2] Andreas Bischoff, Virtual Reality und Streaming-Technologien in der Web-basierten multimedialen Lehre und für Ubiquitous Computing, Dissertation, University of Hagen, Department of Electrical Engineering and Information Technology, 2005 (in print).

[3] Andreas Bischoff. Kollaborative virtuelle Umgebung für Online-Praktika und Seminare. In 39. Regelungstechnisches Kolloquium in Boppard, February 2005.

Teamspeak Audio Conference with Telephone Backup for Synchronous Online Seminars

Andreas Bischoff

Most of today's internet users are connected to it by NAT routers. Network Address Translation (NAT) provides a local network with private non-routable IP addresses. For outgoing connections NAT translates all local to public addresses. For incoming requests NAT is often a problem. Users of audio conferencing tools behind a NAT router have to open ports for incoming connection manually. To avoid any effort for our students we have integrated the Teamspeak [1] audio conference (Voice over IP) software into our online seminar environment [2]. Teamspeak was initially developed to be a 'NAT aware' solution for audio communication in team-based multiplayer games. The Teamspeak server software is distributed for Linux and Windows for free but with a closed source license. Teamspeak clients are available for Windows, Linux and Mac OS X (TeamSpeex). Since Teamspeak is using the audio codecs CELP (5.1 Kbit/s - 6.3 Kbit/s), GSM (14.8 Kbit/s - 16.4 Kbit/s) and Speex (Speex 3.4 Kbit - 25.9 Kbit) a modem line is sufficient to use our online seminar environment.

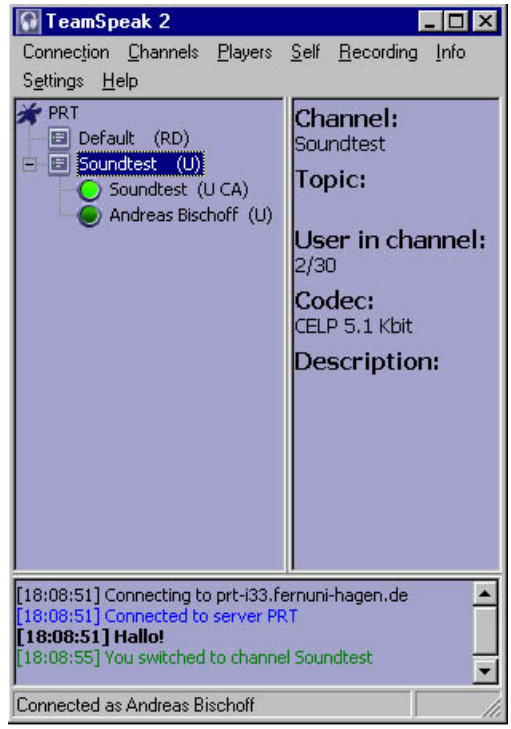


Figure 1: System structure

We have connected a Teamspeak client via a virtual audio device to a SIP Softphone (SIP, **S**ession **I**nitiation **P**rotocol, RFC 3261)[4]. This modified client is used as a backup to access the audio conference over the conventional telephone network. In case of a broken internet connection the users are able to use a standard or a mobile phone to reconnect to the audio conference and continue their seminar presentations.

[1] http://www.goteamspeak.com/

[2] Andreas Bischoff, Virtual Reality und Streaming-Technologien in der Web-basierten multimedialen Lehre und für Ubiquitous Computing, Dissertation, University of Hagen, Department of Electrical Engineering and Information Technology, 2005 (in print).

[3] Andreas Bischoff. Kollaborative virtuelle Umgebung für Online-Praktika und Seminare. In 39. Regelungstechnisches Kolloquium in Boppard, February 2005.

[4] http://www.ietf.org/rfc/rfc3261.txt

Practical exercises in mechatronics with a mobile robot

Ulrich Borgolte

Despite the fact that FernUniversität in Hagen is a distance teaching university, some courses are hardly to understand without ever entering a laboratory. This is especially true for engineering sciences. Therefore, practical exercises are a well established part of studies for electrical engineering. These requirements were even enhanced by the introduction of Master of Science courses.

One of the newly developed modules for the Master programme is “Mechatronics”. It focuses on robots as prototypical mechatronic devices. Within this module, not only stationary robots (industrial robots), but also mobile robots are addressed. Programming of these devices is quite different from common programming. Behaviour based programming, with parallel execution of tasks, is one of the up-to-date programming paradigms in robotics.

The practical exercise for mechatronics introduces to behaviour based programming of mobile robots. The task to be accomplished by the students is: *To drive a mobile robot through a labyrinth, without touching the walls, and to stop at a defined end position*. The robot is a Pioneer 3 AT (fig. 1). Before starting to work with the real robot, a graphical simulation can be done.

Figure 1: Pioneer robot in labyrinth

The students can start with a rough program frame, introducing the major syntactical elements of the programming language COLBERT™. They have to program activities like “follow a wall”, “detect and follow a left corner”, “detect and follow a right corner”, and “detect the end position and stop”.

The students can run the syntactical checks before coming to the labs in Hagen. Current work deals with remote access to the simulation environment. For the time beeing, simulation is done in the laboratory before applying the programs to the real robot. The next organizational step will be to make the simulation environment remotely available. There is even more work to be done to allow remote control of the real robot. This final step will add one more real experiment to the virtual lab environment of the Control Systems Engineering Group at the FernUniversität.

[1] http://prt.fernuni-hagen.de/lehre/PRAKTIKUM/KURZ/roboter.html

A Web-based Design Tool for Control Systems

Michael Gerke, Adolf Huber and Ivan Masár

One of the most important features to support Web-based training for engineering students within the Virtual University environment is the visualization and animation of practical examples given in the courseware context. This is an important add-on functionality, which is rarely available for students of conventional universities. Even simulations can be included into electronic courseware to motivate students to explore the learning subject further on.

Advances Internet techniques provide powerful tools for client-side applications such as complex simulation environments for control problems. Based on the Java Virtual Machine, applets can be included into Web pages to perform various tasks on the host system.

In our case, we developed applets for user input of transfer functions, for control systems analysis and synthesis, and for graphical output of plots.

The design of the user interface included formula parsing for polynomial input or input in MATLAB™ notation. System analysis and synthesis is supported by NYQUIST plots, BODE plots and Root Locus contours.

Figure 1: Input Applet

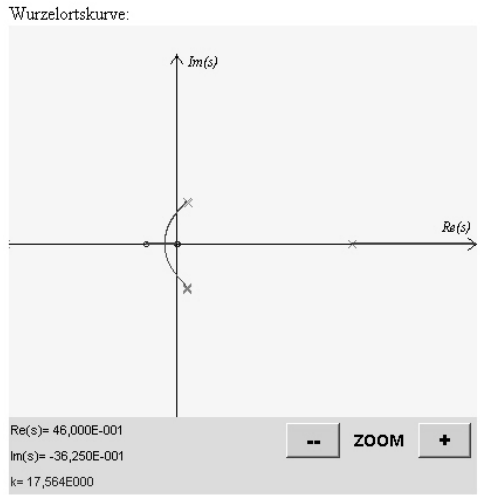


Figure 2: Root Locus contour plot

The Web-based design tool is accessible via the WWW-homepage of our research group (http: \\ prt.fernuni-hagen.de) in our news and information section.

[1] *A. Huber:*
Entwurf und Programmierung von WWW-Anwendungen
zur Analyse von Regelkreisen
Diploma Thesis (in German), Hagen 2005

[2] *M. Gerke, A. Huber, I. Masár:*
A Web-based Design Tool for Control Systems
6th International Virtual University conference
Bratislava, Slovak Republic, December 2005

Further Education for Automation Professionals via Internet

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Typically, automation technicians (ATs) have undergone a two to four years initial vocational training, often combined with an apprentice in an enterprise. The daily work of ATs is quite technical, and requires practical experience and a good understanding of basic principles of automation and control systems in order to maintain, trouble-shoot and solve problems related to automation and control of industrial processes. Non-optimally tuned or even mistuned control loops are the origin for operational problems, reduced product quality, increased production costs, environmental problems, etc. ATs play an important role in operation and maintenance of automation equipment and control systems in all process- and manufacturing industries. The ATs gain a basic understanding and knowledge about automation and control systems from their initial training in automation provided by an educational institution. In spite of this, there is a documented need for specialized, continuous training and practising beyond the basic education. This is also due to organizational issues in many companies. E.g., the ATs are often given few opportunities for attending training courses etc. in order to update their skills. Another example: Even in large companies, there is often only a very small group of people having a background from automation and control. This gives the ATs only a limited opportunity to discuss problems related to their profession with in-house personnel.

The Control Systems Engineering Group at the FernUniversität participates in the European project 'AutoTech', funded by the European Commission, Leonardo da Vinci office. The learning material produced within AutoTech will be composed of traditional learning components like text, presentations, exercises, quizzes and visuals (pictures, videos, interactive animations, virtual reality, etc). However, one of the main innovations in the project is that the learning material will also consist of industrially relevant, innovative and motivating interactive dynamic simulations, games and competitions. Another innovative aspect is the utilization of recent developments in remote experimentation, integrating on-line interactive remote experimentation on real physical laboratory equipment.

The learning components will be available from a flexible repository. The developed courseware can be used stand-alone or integrated as components in blended learning environments. New courses can be configured based on existing, adapted or new learning components. Individual learning components can be integrated in other external Learning Management Systems. As a result of this project, all stakeholders (learners, educational institutions, and learning material providers) in AT vocational training will have access to a much wider range of motivating, practically oriented and industrial relevant learning resources. All components will be available in English and translated into all languages used by the project partners (Spanish, German, Romanian, and Norwegian).

An example for a set of courses in further education for industrial automation is the PLC courseware at University of Hagen. It is targeted towards ATs working in industry. At University of Hagen, it is possible to program a real existing Programmable Logic Control (PLC) via the internet without restrictions. A standard web-browser is the only pre-requisite. With this PLC, a real model railway can be controlled (SPS-Rail).

[1] http://prt.fernuni-hagen.de/pro/autotech/main.html

[2] http://www.pidstop.com/index.php?r_ id=159