52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems
Session 2 - Advances in Control Theory and Control Engineering
Session 3 - Optimisation and Management of Complex Systems and Networked Systems
Session 4 - Intelligent Vehicles and Mobile Systems
Session 5 - Robotics and Motion Systems

TECHNISCHE UNIVERSITÄT
ILMENAU

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

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

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

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

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

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

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

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

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Page

1 Systems Engineering and Intelligent Systems

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

M. Schneider / U. Lehmann / J. Krone / P. Langbein / Ch. Ament / P. Otto / U. Stark / J. Schrickel

Artificial neural network for product-accompanied analysis and control

1. Material behaviour of the side shell

In the context of the project in cooperation with Airbus the material behaviour of several components of a fuselage section is modelled and simulated by the Competence Platform “Computer Vision based on Computational Intelligence (KOPF CV&CI)” with artificial neural network (ANN) at the South Westphalia University of Applied Sciences. For this purpose fuselage components were measured in a series of experiments to model the interrelationship between movement of actors for positioning and corresponding change of component geometry [2]. Every actor can move independently of each other in x-, y-, z-direction. A very exact measuring system delivers the coordinates of the measuring points which are integrated as planned in the fuselage components. With these mesuring points the geometry of the side shell and the position in space is determined. The data sets of every single measuring form the base to develope a simulation model showing the material behaviour of the right side shell in an artificial neural network (ANN). After the data sets had been processed and evaluated, they could be used for training. The training was not accomplished by absolute coordinates of the measuring points but by relative deviations from zero position of side shell.

Movements of controllable actors serve as input to artificial neural network and x-, y- and z-coordinates of every single measuring point serve as output. Due to a low number of data sets an artificial neural network was developed for every single measuring point. In addition, only the main moving direction (=y-direction) of the actors was taken into account to reduce the connections between the neurons. These artificial neural networks were put into a parallel order (figure 1). The predicted position of measuring points meets the high precision request of Airbus, i.e. artificial neural networks are suitable to predict this strong nonlinear material behaviour of fuselage components very well. With a larger number of data sets and taking into account of all possible actor movements it would be better to train the material behaviour in one artificial neural network. So the result of the simulation might be even better. The interaction of measuring points with each other could be trained much better in a neural material model. Therefore the material behaviour of the side shell could be simulated more exactly. Due to the better relationship of connections between neurons to training data sets the neural model by 7 parallel artificial neural networks was favoured concerning the generalization performance.

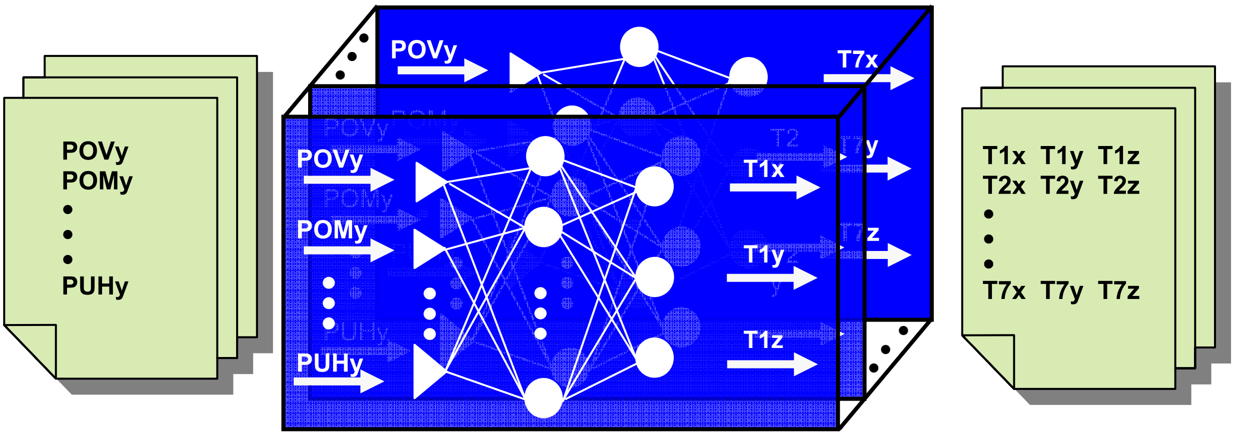

Figure 1: **parallel order of the networks to simulate the material behaviour**

In comparison to the finit elements method artificial neural networks are suitable very well to simulate this strongly nonlinear behaviour of components of a bent extensive fuselage section [1]. The data of process monitoring and prediction shall be used to simulate the process control.

2. Control concept

An aim of the project is to create a concept for production accompanying analysis of component geometry of a fuselage section by artificial neural networks [1]. “At present it is common for fuselage production, first to join extensive bent components to fuselage sections together [3]”. The individual components are riveted together at the component transitions. The fuselage section can stabilize now and is transported to another location for further assembly. This ready fuselage section shall correspond to the construction plan exactly. If the precision is not optimal, special approval procedures for the Aeronautics Federal Office or time- and cost-intensive improvement work are necessary to meet the demanded precision of the geometry of the fuselage section [5].

Various outer influences can have an effect on the components of the fuselage section and can influence the assembly. They shall be compensated automatically by a Computational Intelligence (CI) control concept. “It is not unusual, that the tool finally made produces parts, which one being outside the measure tolerances of the original design sheet … In addition, deviations which are caused by temperature changes in the factory, can change … the measurements of the final part [4].” In predefined intervals a visual measuring system (Computer Vision) delivers the coordinates of the measuring points. These data are led back in control system to ensure the component of a fuselage section corresponding to its specification. Controllable actors can specifically influence the geometry of the fuselage component in context of the permitted limits at measured deviations.

The control process is a neural model with 6 inputs (=actor’s deviation) and 21 outputs (x-, y-, z-deviation of the 7 measuring points) as pointed in chapter 1. The applied controller needs 21 controlled process variable and 6 actuating variables. At the movement of one single actor all 7 measuring points are moved, e.g. no controlled process variable has to be assigned for exactly one actuating variable. With a classic multivariable control this feedback control problem is very difficult to solve because the controlled process variable and actuating variable are coupled ambiguously. A neural controller is able to meet these requirements. The neural model of the material behaviour cannot simply be inverted, because only one correction movement of the actors can return the measuring points into the desired position. A clear solution would not be received by 7 artificial neural networks in parallel. In spite of the low number of data sets only one network was trained. The data sets were partitioned the following way: 76% for training, 14% for validation and 9% for testing.

If one measuring point is out from zero position the neural controller displayes the essential traverse path of the actors to move the measuring points back into zero position.

In change of outer boundary conditions and/or the system behaviour the artificial neural network delivers the traverse path of every single actor. Therefore the geometry of the fuselage section can be kept automatically constant by a CI-control of a close limit of a couple of one-hundredths of a millimetre.

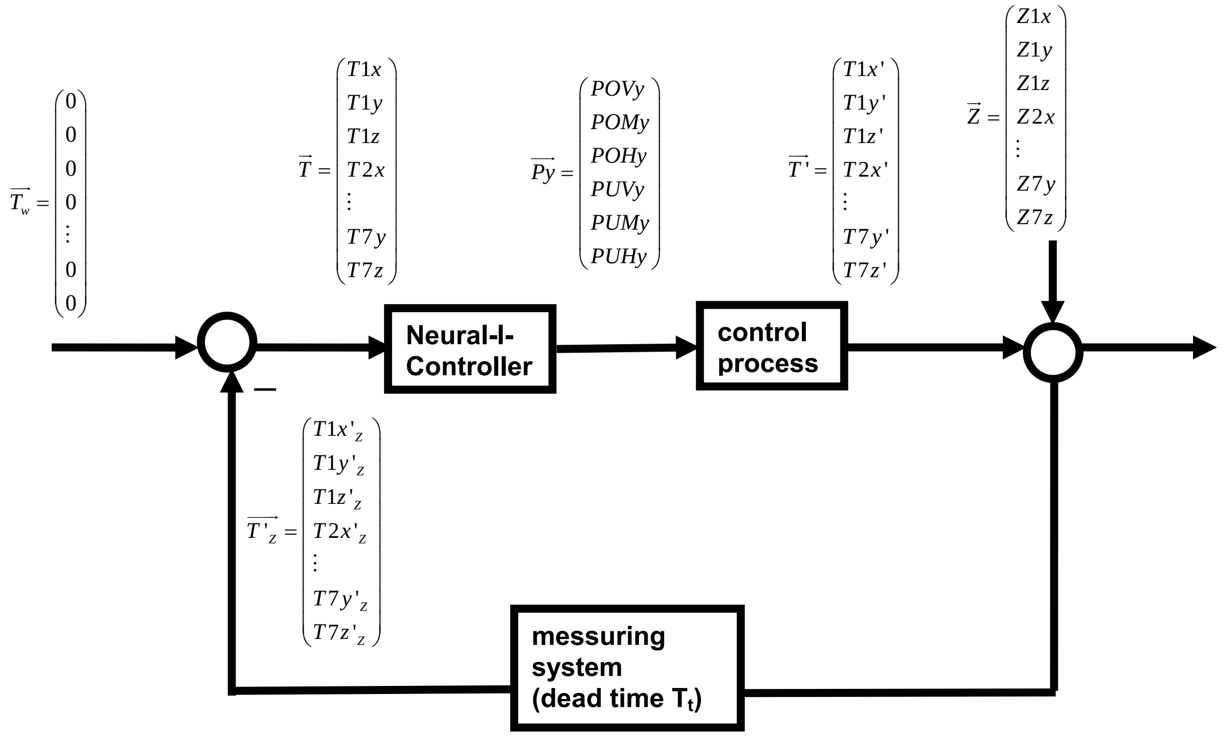

Figure 2: closed loop for simulation

The closed loop (figure 2) is dominated by the dead time. For continuous control an integral element was put in front of the neural controller. The setting rules of Ziegler and Nichols [6] were consulted to dimension the integration time T_i.

$$T_i \approx 3{,}33\ T_t$$

For this simulation model was reached a good simulation result for: $T_i = 4\ T_t$

Therefore oscillation of the closed loop could be prevented. The process model which is influenced by the disturbance input is controlled well.

3. Prospects

This model based control will be tested at a process model and can gradually be integrated into the real production expiry. Control accuracy of this control system by CI-controller can be improved permanently by an ongoing training in regular operation. The applicability of this Neural-I-Controller to side shells of other sections of the same aeroplane model and to side shells of other aeroplane models still has to be assayed. Furthermore the number of data sets should be extended and the simulation model should be tested on the real assembly. Advantages at the production costs could be realised by this CI-control concept.

4. Conclusion

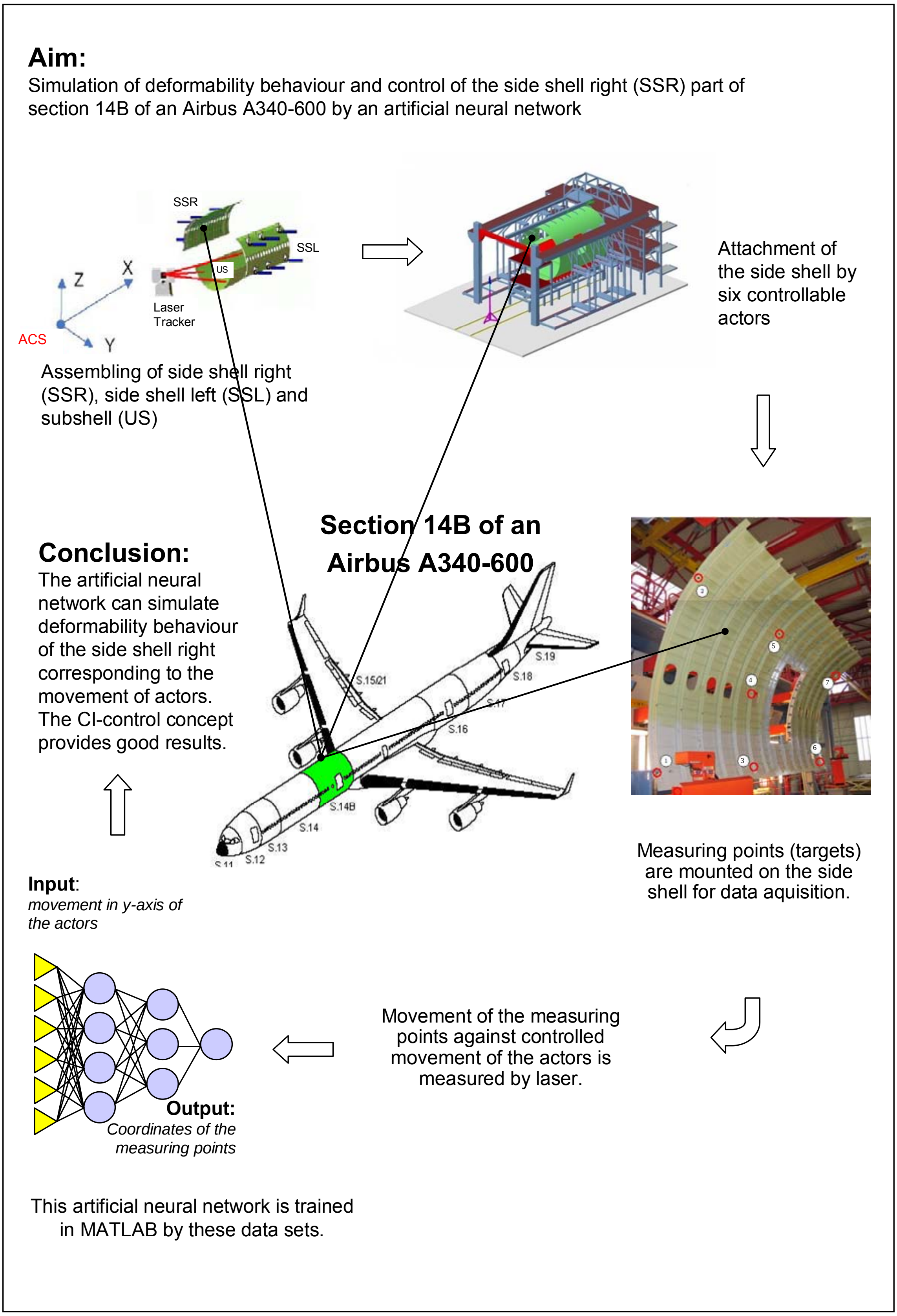

Figure 3: Artificial neural network for production accompanying analysis and control

5. Acknowledgement

The Competence Platform "Computer Vision based on and Computational Intelligence" (http://www.fh-swf.de/cv-ci) is funded by the Ministry of Innovation, Science, Research and Technology of the State of North Rhine-Westphalia.
The authors want to express their sincere thanks to Dipl.-Ing. Ulrich Stark and Dipl.-Ing. Jörg Schrickel from the Airbus Deutschland GmbH for supporting this research by providing real measuring data sets.

References:

[1] R. Tillmann, M. Schneider, J. Krone, U. Lehmann, J. Schrickel, U. Stark, D. Welbhoff: „Airbus - KNN zur fertigungsbegleitenden Analyse und Prozessregelung", Ausstellung "Lebendige Forschung an Fachhochschulen im Landtag NRW", Düsseldorf, 24.01.-02.02.2007
[2] Lehmann, U., Johannes, H., Hohage, S., Woestmann, S.: „Analyse eines Umformprozesses mit KNN und Data Mining", GI/VDI-Computational-Intelligence-Kongress, Baden-Baden im Mai 2000
[3] Patentschrift DE 198 34 703 C 1; Verfahren zur Herstellung, Ausrüstung und Ausstattung eines Flugzeugrumpfes und Vorrichtung zur Durchführung des Verfahrens; Patentinhaber: DaimlerChrysler Aerospace Airbus GmbH, 21129 Hamburg, DE; Veröffentlichungstag der Patenterteilung 30.12.1999
[4] Patentschrift DE 693 31 430 T 2; Platten und Rumpfmontage; Patentinhaber: The Boing Co., Seattle, Wash., US; Veröffentlichungstag im Patentblatt 07.11.2002
[5] Prof. Dr.-Ing. Klaus Rall, Dr.-Ing. habil. Jörg Wollnak, TU Hamburg-Harburg, „Genauigkeit muss nicht teuer sein"; SPEKTRUM: Special Luftfahrtforschung 2003
[6] Prof. Dr.-Ing. Holger Wendt, Prof. Dr.-Ing. Wolfgang Wendt: „Taschenbuch der Regelungstechnik", Verlag Harri Deutsch, 5. Auflage, 2003

Authors:

Dipl.-Ing. M. Schneider, Prof. U. Lehmann, Prof. Dr.-Ing. J. Krone, Prof. Dr.-Ing. habil. P. Langbein
Fachhochschule Südwestfalen
South Westphalia Universitiy of Applied Sciences
Frauenstuhlweg 31
D-58644 Iserlohn, Germany
Phone: +49/(0)2371/566-180
Fax: +49/(0)2371/566-209
E-mail: MSchneider@fh-swf.de, Lehmann@fh-swf.de, Krone@fh-swf.de, langbein@fh-swf.de

Prof. Dr.-Ing. habil. Ch. Ament, Priv.-Doz. Dr.-Ing. habil. P. Otto
Technische Universität Ilmenau
Faculty of Computer Sciences and Automation
System Analysis Group
Postfach 10 05 65
D-98684 Ilmenau, Germany
Phone: +49/(0)3677/69-2815, -2773
Fax: +49/(0)3677/69-1434
E-mail: christoph.ament@tu-ilmenau.de, peter.otto@tu-ilmenau.de

Dipl.-Ing. U. Stark, Dipl.-Ing. J. Schrickel
Airbus Deutschland GmbH
Kreetslag 10
D-21129 Hamburg, Germany
Phone: +49/(0)40/743-81268, -85167
Fax: +49/(0)40/743-74794
E-mail: ulrich.stark@airbus.com, joerg.schrickel@airbus.com