

52. IWK

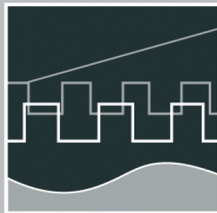
Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium



PROCEEDINGS

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



Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen
Nationalbibliografie; 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

© Technische Universität Ilmenau (Thür.) 2007

Diese Publikationen und alle in ihr enthaltenen Beiträge und Abbildungen sind urheberrechtlich geschützt. Mit Ausnahme der gesetzlich zugelassenen Fälle ist eine Verwertung ohne Einwilligung der Redaktion strafbar.

Preface

Dear Participants,

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

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

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

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

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

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.

I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau



Professor Christoph Ament
Head of Organisation

Table of Contents

CONTENTS

	Page
1 Systems Engineering and Intelligent Systems	
A. Yu. Nedelina, W. Fengler DIPLAN: Distributed Planner for Decision Support Systems	3
O. Sokolov, M. Wagenknecht, U. Gocht Multiagent Intelligent Diagnostics of Arising Faults	9
V. Nissen Management Applications of Fuzzy Control	15
O. G. Rudenko, A. A. Bessonov, P. Otto A Method for Information Coding in CMAC Networks	21
Ye. Bodyanskiy, P. Otto, I. Pliss, N. Teslenko Nonlinear process identification and modeling using general regression neuro-fuzzy network	27
Ye. Bodyanskiy, Ye. Gorshkov, V. Kolodyazhniy, P. Otto Evolving Network Based on Double Neo-Fuzzy Neurons	35
Ch. Wachten, Ch. Ament, C. Müller, H. Reinecke Modeling of a Laser Tracker System with Galvanometer Scanner	41
K. Lüttkopf, M. Abel, B. Eylert Statistics of the truck activity on German Motorways	47
K. Meissner, H. Hensel A 3D process information display to visualize complex process conditions in the process industry	53
F.-F. Steege, C. Martin, H.-M. Groß Recent Advances in the Estimation of Pointing Poses on Monocular Images for Human-Robot Interaction	59
A. González, H. Fernlund, J. Ekblad After Action Review by Comparison – an Approach to Automatically Evaluating Trainee Performance in Training Exercise	65
R. Suzuki, N. Fujiki, Y. Taru, N. Kobayashi, E. P. Hofer Internal Model Control for Assistive Devices in Rehabilitation Technology	71
D. Sommer, M. Golz Feature Reduction for Microsleep Detection	77

F. Müller, A. Wenzel, J. Wernstedt A new strategy for on-line Monitoring and Competence Assignment to Driver and Vehicle	83
V. Borikov Linear Parameter-Oriented Model of Microplasma Process in Electrolyte Solutions	89
A. Avshalumov, G. Filaretov Detection and Analysis of Impulse Point Sequences on Correlated Disturbance Phone	95
H. Salzwedel Complex Systems Design Automation in the Presence of Bounded and Statistical Uncertainties	101
G. J. Nalepa, I. Wojnicki Filling the Semantic Gaps in Systems Engineering	107
R. Knauf Compiling Experience into Knowledge	113
R. Knauf, S. Tsuruta, Y. Sakurai Toward Knowledge Engineering with Didactic Knowledge	119
2 Advances in Control Theory and Control Engineering	
U. Konigorski, A. López Output Coupling by Dynamic Output Feedback	129
H. Toossian Shandiz, A. Hajipoor Chaos in the Fractional Order Chua System and its Control	135
O. Katernoga, V. Popov, A. Potapovich, G. Davydau Methods for Stability Analysis of Nonlinear Control Systems with Time Delay for Application in Automatic Devices	141
J. Zimmermann, O. Sawodny Modelling and Control of a X-Y-Fine-Positioning Table	145
A. Winkler, J. Suchý Position Based Force Control of an Industrial Manipulator	151
E. Arnold, J. Neupert, O. Sawodny, K. Schneider Trajectory Tracking for Boom Cranes Based on Nonlinear Control and Optimal Trajectory Generation	157

K. Shaposhnikov, V. Astakhov The method of ortogonal projections in problems of the stationary magnetic field computation	165
J. Naumenko The computing of sinusoidal magnetic fields in presence of the surface with bounded conductivity	167
K. Bayramkulov, V. Astakhov The method of the boundary equations in problems of computing static and stationary fields on the topological graph	169
T. Kochubey, V. Astakhov The computation of magnetic field in the presence of ideal conductors using the Integral-differential equation of the first kind	171
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	173
I. Jawish The Improvement of Traveling Responses of a Subway Train using Fuzzy Logic Techniques	179
Y. Gu, H. Su, J. Chu An Approach for Transforming Nonlinear System Modeled by the Feedforward Neural Networks to Discrete Uncertain Linear System	185
3 Optimisation and Management of Complex Systems and Networked Systems	
R. Franke, J. Doppelhammer Advanced model based control in the Industrial IT System 800xA	193
H. Gerbracht, P. Li, W. Hong An efficient optimization approach to optimal control of large-scale processes	199
T. N. Pham, B. Wutke Modifying the Bellman's dynamic programming to the solution of the discrete multi-criteria optimization problem under fuzziness in long-term planning	205
S. Ritter, P. Bretschneider Optimale Planung und Betriebsführung der Energieversorgung im liberalisierten Energiemarkt	211
P. Bretschneider, D. Westermann Intelligente Energiesysteme: Chancen und Potentiale von IuK-Technologien	217

Z. Lu, Y. Zhong, Yu. Wu, J. Wu WSReMS: A Novel WSDM-based System Resource Management Scheme	223
M. Heit, E. Jennenchen, V. Kruglyak, D. Westermann Simulation des Strommarktes unter Verwendung von Petrinetzen	229
O. Sauer, M. Ebel Engineering of production monitoring & control systems	237
C. Behn, K. Zimmermann Biologically inspired Locomotion Systems and Adaptive Control	245
J. W. Vervoorst, T. Kopfstedt Mission Planning for UAV Swarms	251
M. Kaufmann, G. Bretthauer Development and composition of control logic networks for distributed mechatronic systems in a heterogeneous architecture	257
T. Kopfstedt, J. W. Vervoorst Formation Control for Groups of Mobile Robots Using a Hierarchical Controller Structure	263
M. Abel, Th. Lohfelder Simulation of the Communication Behaviour of the German Toll System	269
P. Hilgers, Ch. Ament Control in Digital Sensor-Actuator-Networks	275
C. Saul, A. Mitschele-Thiel, A. Diab, M. Abd rabou Kalil A Survey of MAC Protocols in Wireless Sensor Networks	281
T. Rossbach, M. Götze, A. Schreiber, M. Eifart, W. Kattanek Wireless Sensor Networks at their Limits – Design Considerations and Prototype Experiments	287
Y. Zhong, J. Ma Ring Domain-Based Key Management in Wireless Sensor Network	293
V. Nissen Automatic Forecast Model Selection in SAP Business Information Warehouse under Noise Conditions	299
M. Kühn, F. Richter, H. Salzwedel Process simulation for significant efficiency gains in clinical departments – practical example of a cancer clinic	305

D. Westermann, M. Kratz, St. Kümmerling, P. Meyer Architektur eines Simulators für Energie-, Informations- und Kommunikationstechnologien	311
P. Moreno, D. Westermann, P. Müller, F. Büchner Einsatzoptimierung von dezentralen netzgekoppelten Stromerzeugungsanlagen (DEA) in Verteilnetzen durch Erhöhung des Automatisierungsgrades	317
M. Heit, S. Rozhenko, M. Kryvenka, D. Westermann Mathematische Bewertung von Engpass-Situationen in Transportnetzen elektrischer Energie mittels lastflussbasierter Auktion	331
M. Lemmel, M. Schnatmeyer RFID-Technology in Warehouse Logistics	339
V. Krugljak, M. Heit, D. Westermann Approaches for modelling power market: A Comparison.	345
St. Kümmerling, N. Döring, A. Friedemann, M. Kratz, D. Westermann Demand-Side-Management in Privathaushalten – Der eBox-Ansatz	351
4 Intelligent Vehicles and Mobile Systems	
A. P. Aguiar, R. Ghabchelloo, A. Pascoal, C. Silvestre , F. Vanni Coordinated Path following of Multiple Marine Vehicles: Theoretical Issues and Practical Constraints	359
R. Engel, J. Kalwa Robust Relative Positioning of Multiple Underwater Vehicles	365
M. Jacobi, T. Pfützenreuter, T. Glotzbach, M. Schneider A 3D Simulation and Visualisation Environment for Unmanned Vehicles in Underwater Scenarios	371
M. Schneider, M. Eichhorn, T. Glotzbach, P. Otto A High-Level Simulator for heterogeneous marine vehicle teams under real constraints	377
A. Zangrilli, A. Picini Unmanned Marine Vehicles working in cooperation: market trends and technological requirements	383
T. Glotzbach, P. Otto, M. Schneider, M. Marinov A Concept for Team-Orientated Mission Planning and Formal Language Verification for Heterogeneous Unmanned Vehicles	389

M. A. Arredondo, A. Cormack SeeTrack: Situation Awareness Tool for Heterogeneous Vehicles	395
J. C. Ferreira, P. B. Maia, A. Lucia, A. I. Zapaniotis Virtual Prototyping of an Innovative Urban Vehicle	401
A. Wenzel, A. Gehr, T. Glotzbach, F. Müller Superfour-in: An all-terrain wheelchair with monitoring possibilities to enhance the life quality of people with walking disability	407
Th. Krause, P. Protzel Verteiltes, dynamisches Antriebssystem zur Steuerung eines Luftschiffes	413
T. Behrmann, M. Lemmel Vehicle with pure electric hybrid energy storage system	419
Ch. Schröter, M. Höchemer, H.-M. Groß A Particle Filter for the Dynamic Window Approach to Mobile Robot Control	425
M. Schenderlein, K. Debes, A. Koenig, H.-M. Groß Appearance-based Visual Localisation in Outdoor Environments with an Omnidirectional Camera	431
G. Al Zeer, A. Nabout, B. Tibken Hindernsvermeidung für Mobile Roboter mittels Ausweichecken	437
5 Robotics and Motion Systems	
Ch. Schröter, H.-M. Groß Efficient Gridmaps for SLAM with Rao-Blackwellized Particle Filters	445
St. Müller, A. Scheidig, A. Ober, H.-M. Groß Making Mobile Robots Smarter by Probabilistic User Modeling and Tracking	451
A. Swerdlow, T. Machmer, K. Kroschel, A. Laubenheimer, S. Richter Opto-acoustical Scene Analysis for a Humanoid Robot	457
A. Ahranovich, S. Karpovich, K. Zimmermann Multicoordinate Positioning System Design and Simulation	463
A. Balkovoy, V. Cacenkin, G. Slivinskaia Statical and dynamical accuracy of direct drive servo systems	469
Y. Litvinov, S. Karpovich, A. Ahranovich The 6-DOF Spatial Parallel Mechanism Control System Computer Simulation	477

V. Lysenko, W. Mintchenya, K. Zimmermann 483
Minimization of the number of actuators in legged robots using biological objects

J. Kroneis, T. Gastauer, S. Liu, B. Sauer 489
Flexible modeling and vibration analysis of a parallel robot with numerical and analytical methods for the purpose of active vibration damping

A. Amthor, T. Hausotte, G. Jäger, P. Li 495
Friction Modeling on Nanometerscale and Experimental Verification

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

V. Piwek, B. Kuhfuss, S. Allers 503
Feed drivers – Synchronized Motion is leading to a process optimization

O. Sokolov / M. Wagenknecht / U. Gocht

Multiagent Intelligent Diagnostics of Arising Faults

Decision Support Systems

This paper is devoted to fault diagnosis problems using decision making mechanism based on multiagent approach. We investigate dynamic systems which can be diagnosed by symptom-fault rule bases. The main question to be answered is what faults produce observable symptoms in the first moments of their appearance. To solve this task we propose to use a set of agents for making hypothesis about symptoms and coming to an agreement.

1 Symptom-fault model

We use $F = \{f_l\}_{l=1}^{N_F}$ and $S = \{s_m\}_{m=1}^{N_S}$ to denote the finite sets of all possible faults and symptoms, respectively. There is also multi valued mapping

$$\psi : S \rightarrow F \quad (1)$$

that can be presented as a **binary diagnostic matrix** like in Table 1. This matrix reflects the influence of relations between elements of sets S and F as numbers from $I = \{0,1\}$.

Table 1: Example of binary diagnostic matrix

S / F	f_1	...	f_{N_F}
s_1	1	...	0
...	0	...	1
s_{N_S}	1	...	1

Let a set of agents are responsible for observing of symptoms and making hypothesis about possible faults [2].

The main mission of agents in diagnostic task is to perceive the symptoms on first stages of their arising and recognize caused faults.

Let the set of agents given by $A = \{a_i\}_{i=1}^{N_A}$, $N_A \leq N_F$ and let exists a map

$$\xi : A \rightarrow F \quad (2)$$

Let each agent is responsible for several faults but one fault can be recognized by only one agent. The way in which the set F is divided by agents from A is a state of art of the subject diagnostic area. The natural manner is to divide faults according to subsystems of diagnostic objects [5].

2 Multi-agent diagnosis model

Let $S_o \subseteq S$ be a subset of symptoms observed by some management application. It reduces to the generation of an appropriate logical expression from (1) in Conjunctive Normal Form, i.e.

from $\psi|_{S_o} : S \rightarrow F$ we can get

$$\sigma = \bigvee_{i=1}^{D(S_o)} \left(\bigwedge_{j \in C_i(S_o)} f_j \right) \quad (3)$$

where $D(S_o)$ is a number of disjunctions in the formula, $C_i(S_o)$ is a set of indexes in the i^{th} conjunction expression.

Formula (3) gives the *minimum number of disjunctions* of faults that cause the set of observed symptoms. It is a necessary condition for getting S_o from diagnostic matrix.

Let $C = \{a_{1_c}, \dots, a_{N_c}\}$ be a set of agents responsible for σ . For each agent a_{j_c} there is a set of appropriate faults $Af_{j_c} = \{f_{1_{j_c}}, \dots, f_{N_{j_c}}\} \subset F$.

We propose the following heuristic recurrent procedure for choosing the set of testing faults from each element of $F_C = \{Af_{1_c}, \dots, Af_{N_c}\}$.

Let $\sigma_0 = \bigvee_{i=1}^{D_0} \left(\bigwedge_{j \in C_i^0} f_j \right)$ be an initial formula (3) where $D_0 = D(S_o)$ is the number of disjunctions in the formula; $C_i^0 = C_i(S_o)$ is the set of indexes in the i^{th} conjunction expression. Let $F_0 = \{F_{1_c}^0, \dots, F_{N_c}^0\} = F_C$ be the set of possible faults that caused the observed symptoms distributed on agents from C . Further we propose the procedure that performs by each agent Ag from $C = \{a_{1_c}, \dots, a_{N_c}\}$ at the k^{th} step simultaneously. We call this an α -**procedure**.

1. Refresh

$$\sigma_k = \bigvee_{i=1}^{D_k} \left(\bigwedge_{j \in C_i^k} f_j \right)$$

according to the result of faults checking at the previous step and abbreviate by cancellation excessive variables and false conjunctions (executed one time at each step).

2. **If** $F_{Ag}^k \neq \emptyset$ **then** choose one fault f_{Ag} from F_{Ag}^k that belongs to the conjunction in (3) with minimal length $\min \text{card}(C_i^k)$. If there are several conjunctions with the same length we apply a random choice. Set $F_{Ag}^{k+1} = F_{Ag}^k \setminus f_{Ag}$ **else stop** testing process for the current agent.
3. Check f_{Ag} and set $f_{Ag} = \{true, false\}$.
4. Set global state $k = k + 1$.

The proposed algorithm is converging due to the reliable set of symptoms, the truthful binary diagnosis matrix and the step-by-step reducing of the set of possible faults.

It is possible to improve the procedure and do not consider all agents simultaneously but one after another. In cooperation logic such model is called β -coalition contrary to the α -coalition for the case described above [5]. The β -coalition foresees the conditional coalition when the current decision strongly depends on the previous one.

The β -**procedure** is as follows.

1. Determine

$$\sigma_k = \bigvee_{i=1}^{D_k} \left(\bigwedge_{j \in C_i^k} f_j \right)$$

from the previous step or after modification at the current step.

2. **If** $F_{Ag}^k \neq \emptyset$ **then** choose one fault f_{Ag} from the set F_{Ag}^k that belongs to the conjunction in (3) with minimal length $\min \text{card}(C_i^k)$. Set $F_{Ag}^{k+1} = F_{Ag}^k \setminus f_{Ag}$ **else** stop testing the process for the current agent.
3. **If** $\min \text{card}(C_i^k) = 1$ and $F_{Ag}^{k+1} = \emptyset$ **then** set $f_{Ag} = \text{true}$ without checking. **else** check f_{Ag} and set the appropriate value $f_{Ag} = \{\text{true}, \text{false}\}$.
4. Refresh

$$\sigma_k^{\text{mod}_{Ag}} = \bigvee_{i=1}^{D_k} \left(\bigwedge_{j \in C_i^k} f_j \right)$$
 according to the value $f_{Ag} = \{\text{true}, \text{false}\}$ and abbreviate by cancelling excessive variables and false conjunctions.
5. Send to the next agent (from $C = \{a_{1c}, \dots, a_{Nc}\}$) the modified formula $\sigma_k^{\text{mod}_{Ag}}$. If this agent is last in the list then set $\sigma_{k+1} = \sigma_k^{\text{mod}_{Ag}}$.
6. After testing (4.9) by the remaining agents set global state $k = k + 1$.

Step 5 demands to set the schedule of agents for sending information. This schedule may be organized by

- A list in $C = \{a_{1c}, \dots, a_{Nc}\}$;
- randomly;
- in inverted range of cardinality of elements in $F_k = \{F_{1c}^k, \dots, F_{Nc}^k\}$.

3 Example

Let us consider the example of three-tank system (Fig.1).

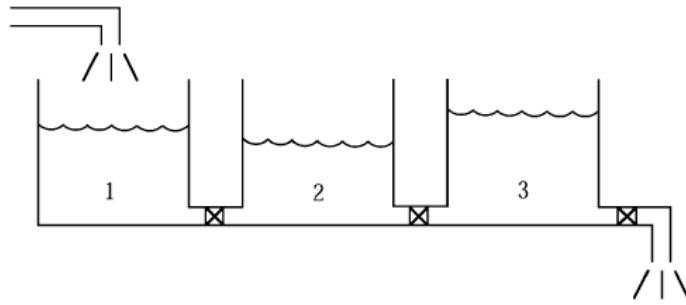


Fig.1. Three-tank system

The list of possible faults in this system is given in Table 2 [2].

Table 2: Set of faults of three-tank system

f_k	Fault description
f_1	fault of the flow sensor F
f_2	fault of the level sensor L_1
f_3	fault of the level sensor L_2
f_4	fault of the level sensor L_3
f_5	fault of the control path U
f_6	fault of the control-valve
f_7	fault of the pump
f_8	lack of medium

f_9	partial clogging of the channel between the tanks Z_1 and Z_2
f_{10}	partial clogging of the channel between the tanks Z_2 and Z_3
f_{11}	partial clogging of outlet
f_{12}	leaking from the tank Z_1
f_{13}	leaking from the tank Z_2
f_{14}	leaking from the tank Z_3

Let us assume that fault detection is realized with the use of five residuals generated on the grounds of the physical equations of the system [2]. These residuals generate the symptoms $S = \{s_i\}_{i=1}^{N_s=5}$.

Let us represent symptom-fault mapping with following binary diagnostic matrix (Table 3) [2].

Table 3: Binary diagnostic matrix

S/F	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}
s_1	1				1	1	1	1						
s_2	1	1	1						1			1		
s_3		1	1	1					1	1			1	
s_4			1	1						1	1			1
s_5	1	1	1	1							1	1	1	1

Let us create agents that are response for faults. The possible distribution of agents are presented in Table 5.3.

Table 4: Assignment of agents to faults

Unit	Agent	List of faults
Tank Z_1	a_1	f_2, f_9, f_{12}
Tank Z_2	a_2	f_3, f_{10}, f_{13}
Tank Z_3	a_3	f_4, f_{11}, f_{14}
Pump	a_4	f_1, f_5, f_6, f_7, f_8

Our model has following body:

$$A = \{a_1, a_2, a_3, a_4\}, F = \{f_1, \dots, f_{14}\}, Af_1 = \{f_2, f_9, f_{12}\}, Af_2 = \{f_3, f_{10}, f_{13}\},$$

$$Af_3 = \{f_4, f_{11}, f_{14}\}, Af_4 = \{f_1, f_5, f_6, f_7, f_8\},$$

Let the following event takes place – $S_o = \{s_2, s_3, s_5\}$.

$$\text{Then we have } \sigma = f_2 \vee (f_9 \wedge f_{13}) \vee (f_9 \wedge f_{12}) \vee (f_{12} \wedge f_{13}),$$

Let us apply α -procedure.

We have now two agents responsible for faults - $C = \{a_1, a_3\}$.

$$\text{Besides, } F^0 = \{F_1^0, F_3^0\} = \{\{f_2, f_9, f_{12}\}, \{f_4, f_{11}, f_{14}\}\}.$$

Step	Action	
0	$\sigma_0 = f_2 \vee (f_9 \wedge f_{13}) \vee (f_9 \wedge f_{12}) \vee (f_{12} \wedge f_{13})$ $C_1^0 = \{2\}, C_2^0 = \{9,13\}, C_3^0 = \{9,12\}, C_4^0 = \{12,13\}$	
0	$Ag = a_1;$ $\min \text{card}(C_i^0) = 1;$ $f_{Ag} = f_2;$	$Ag = a_3;$ $\min \text{card}(C_i^0) = 2;$ $f_{Ag} = f_{12};$
0	Checking: $f_2 = \text{false}$	Checking: $f_{12} = \text{true}$

1	$\sigma_1 = f_9 \vee f_{13}$ $C_1^1 = \{9\}, C_2^1 = \{13\}$	
1	$Ag = a_1;$ $\min card(C_i^0) = 1;$ $f_{Ag} = f_9;$	$Ag = a_3;$ $\min card(C_i^0) = 1;$ $f_{Ag} = f_{13};$
1	Checking: $f_9 = false$	Checking: $f_{13} = true$

As it easy to see in this case we check all possible faults from the initial list and do not get a profit in compare with consecutive search except parallel calculation.

Let us apply β - procedure now.

Step	Action	
0	$\sigma_0 = f_2 \vee (f_9 \wedge f_{13}) \vee (f_9 \wedge f_{12}) \vee (f_{12} \wedge f_{13})$ $C_1^0 = \{2\}, C_2^0 = \{9,13\}, C_3^0 = \{9,12\}, C_4^0 = \{12,13\}$	
0	$Ag = a_1;$ $\min card(C_i^0) = 1;$ $f_{Ag} = f_2;$ Checking: $f_2 = false$	
0	$\sigma_0^{\text{mod}_{a_1}} = (f_9 \wedge f_{13}) \vee (f_9 \wedge f_{12}) \vee (f_{12} \wedge f_{13})$ $C_1^{0\text{mod}_{a_1}} = \{9,13\}, C_2^{0\text{mod}_{a_1}} = \{9,12\}, C_3^{0\text{mod}_{a_1}} = \{12,13\}$	
0		$Ag = a_3;$ $\min card(C_i^0) = 2;$ $f_{Ag} = f_{12};$ Checking: $f_{12} = true$
1	$\sigma_1 = f_9 \vee f_{13}$ $C_1^1 = \{9\}, C_2^1 = \{13\}$	
1	$Ag = a_1;$ $\min card(C_i^0) = 1;$ $f_{Ag} = f_9;$ Checking: $f_9 = false$	
1	$\sigma_1^{\text{mod}_{a_1}} = f_{13}$	
1		$Ag = a_3;$ $\min card(C_i^0) = 1;$ $f_{Ag} = f_{13};$ Setting: $f_{13} = true$

Using β - procedure for this case reduce number of fault checking to three times and substitute checking process by setting.

Remark. We do not draw attention now on procedure of fault checking but we understand that this is some deeply investigation of symptoms dynamic contrary to

identification of symptom to obtaining the set of observed symptoms S_o . Moreover the checking procedure may include additional actions (like computational and even mechanical) to recognize suspected fault. That is why even though big reduce of checking procedure is more than is required.

Conclusion

Due to the distributional character of fault diagnosis and necessity of taking into account different uncertainties during the diagnosis process the multi-agent methodology has been proposed. We showed that the principle of assigning the agent to subsystems in this case is also useful. Then the local knowledge base of agents and rules for communications can precise the possible diagnosis in addition to the ordinary binary or fuzzy diagnostic matrix.

As a result of this investigation we could propose engineering methods for applying multi-agent methods to fault diagnosis problems.

Acknowledgement

This research has partially been supported by the Saxon Ministry of Sciences and Art (Germany).

References:

- [1] R. Isermann. Fault-Diagnosis Systems. An Introduction from Fault Detection to Fault Tolerance. Springer, 2006.
- [2] Soo Young Eo, Tae Suk Chang, Dongil Shin, En Sup Yoon. Cooperative problem solving in diagnostic agents for chemical processes. Computer & Chemical Engineering 24 (2000) 729 – 734.
- [3] M. Wooldridge. An introduction to multi-agent systems. John Wiley&Sons. 2001.
- [4] W. Hoek, M. Wooldridge. On the logic of cooperation and propositional control. Artificial intelligence 164 (2005) 81-119.
- [5] B.D. Pomeroy, H.A. Spang, M.E. Dausch. Event-based architecture for diagnosis in control advisory systems. Artificial Intelligence in Engineering 5 (1990) 174-181.

Authors:

Prof. Dr. Oleksandr Sokolov
National Aerospace University,
Tchkalov str., 17
61070 Kharkiv, Ukraine
Phone: ++38 057 707 43 04
Fax: ++38 057 315 11 31
E-mail: asokolov@xai.edu.ua

Dr. Michael Wagenknecht
University of Applied Sciences Zittau/Goerlitz, IPM
Theodor-Koerner-Allee 16
02763 Zittau, Germany
Phone: ++49 (0) 3583 61 1546
Fax: ++49 (0) 3583 61 1288
E-mail: m.wagenknecht@hs-zigr.de

Dr. Ulrike Gocht
University of Applied Sciences Zittau/Goerlitz, IPM
Theodor-Koerner-Allee 16
02763 Zittau, Germany
Phone: ++49 (0) 3583 61 1546
Fax: ++49 (0) 3583 61 1288
E-mail: u.gocht@hs-zigr.de