A4.3 Model-Based Process Optimisation and Control

Time: Tuesday, 14.09.2010
Location: Humboldt-Building, Lecture Room 013
Chairman: Ch. Ament (DE-Ilmenau)

1:30 p.m.	G. Filaretov, A. Sh. Avshalumov (RU-Moskau)

Cascade Artificial Neural Networks
New variant of artificial neural networks (ANN), named by cascade ANN (CANN), is proposed. Such networks are formed as a cascade connection of at least two ANN, may be of different types. CANN differ from known variants of hybrid networks by organization of training process: different training samples for training of different cascades are used; these training sam-ples are formed on a basis of results on the training ANN of a previous cascade by sorting initial sample elements and/or using some conversation of initial information. In whole the training process is realized sequentially from the first cascade to the last. The sphere of application CANN – data analysis applying to significantly heterogeneous situations, that may occur when solving of some typical tasks, such as: - classification with differently remote classes, when points of some classes are remote from each other on significant distances and so are easily separated, at the same time points of some other classes are small remote from each other and it is difficult to separate them; - classification with differently informative data and/or with variables of different types (quantitative, qualitative, ordinal, ranked); - developing a model of an object at presence of several operation modes. Possibilities of the proposed neural networks type are demonstrated with examples of the de-velopment of classifier for medical diagnostic complex, the construction of ecological model for radon content forecasting in atmosphere of mining working and - mathematical model of a unit of pharmaceutical purpose.

1:50 p.m.	A. Bulgakov, S. Zaghlul Saeed Al-Khayyt (RU-Novotscherkassk)

Neural Network for Non-Smooth Nonlinear Approximation
Model-Based Process Optimisation and Control Nonlinearities are available in control systems frequently due to the nature of most physical systems. Many physical components of control systems have non-smooth nonlinear characteristics such as dead-zone, hysteresis, saturation, friction, backlash and various nonlinear relations between system variables. The adaptive control of nonlinear systems has recently made significant advances. The most common NN architectures used in nonlinear control applications are the multilayer perceptron (MLP) and the radial basis function (RBF) NN. It is known that the use of feed forward neural network with the back propagation (BP) learning algorithm causes problems with local minima, saddle points and the algorithm itself has a very slow convergence rate. Thus, its use is limited to off-line training applications. In this work, we investigated the performance of the radial basis function neural network for non-smooth nonlinear approximation. The neural net work is trained on-line to compensate the nonlinearities such as friction and backlash. The results are presented to illustrate the advantages of the proposed neural network. The Radial Basis Function NN has a dynamic structure due to the pruning strategy, thus it has convergence to the desired target, which makes it suitable for real-time on-line learning. Simulation's results show the effectiveness of the radial basis function neural network for approximation the nonlinearities such of friction and backlash.

2:10 p.m.	Y. Bodyanskiy, O. Vynokurova (UA-Kharkov), P. Otto (DE-Ilmenau), J. Sokolovskyy, O. Petryanych (UA-Lviv)

Adaptive controller for nonlinear dynamic non-stationary stochastic plant based on real time neo-fuzzy-model

Nowadays a large number of the nonlinear dynamic non-stationary control systems synthesis methods have been developed. But implementation of such systems usually requires the knowledge of the exact control plant model, which often is a rather complex task. Considering this it seems reasonable to use the approaches based on computational intelligence approaches, notably hybrid neuro-fuzzy- and neo-fuzzy-systems. Such systems are a powerful tool for the control plant identification under current and a priori uncertainty especially in real time. For the plant identification we have used an adaptive model based on the neo-fuzzy-neuron [1], which has rather simple neuro-fuzzy architecture of the zeroth order Takagi-Sugeno-Kang neuro-fuzzy system type and is characterized by high tuning rate and simplicity of both software and hardware implementation. Using adaptive control methods the controller based on neo-fuzzy-model with generalized minimum variance and constraint on the power with the intellectual parameter definition is proposed. The advantage of the proposed controller is a convergence rate [2] increasing due to quasi linearity of its structure, which allows to control the nonlinear non-stationary processes. The experiments were carried out on the real technical task, included the process of wood desiccation modeling and control. Using the proposed adaptive controller allows to increase the quality of the wood desiccation process providing the required humidity level or the electric power consumption constraints.

2:30 p.m.	Ch. Arnold, B. Cuno (DE-Fulda), Ch. Ament (DE-Ilmenau)

An Approach for the Control Error-Calculation Under Fuzziness

In some automation tasks the final demanded values, basically the process-variables are not defined by means of fixed set-points. They are rather based on tolerance values (ranges), thresholds, classified limits or multi-valued states. Particularly, in the area of air conditioning and climate management, only rough values of set point are available: mainly because climatic requirements are often linguistically described and provided with lack of knowledge. These characteristics suggest incorporating fuzzy-theory, using fuzzy-numbers and fuzzy-intervals to formulate set-points. This representation contains additional benefits, such as offering a transparent method considering many requirements (multi-objective goals) and linguistic hedges by fuzzy-modifiers. Furthermore, the acquisition of process-variables is rather uncertain. At a first level errors are caused by the inaccuracy of sensors. More different error sources are such as model inexactness (differences) or stochastic influences. Hence measured, observed and predicted process-variables are always vague. This uncertainness can also be described using fuzzy- numbers and fuzzy-intervals. Typical tasks of automation are based on the control error calculation (comparison of desired- and actual-values), with the question however arising how the fuzziness aspect can be taken into account; this problem is only discussed in a few papers. The submitted paper clarifies options to represent set-points and actual-values using fuzzy-theory, depicts problems in calculation of control errors and proposes a novel method. This can be applied for diagnostics-, monitoring- and optimization-tasks, especially for predictive concepts. Index Terms: fuzzy decision making, predictive control strategies, multistage fuzzy control, desired-actual value comparison under fuzziness.

2:50 – 3:10 p.m. Coffee break

3:10 p.m.	S. Pan, H. Su, Y. Gu (CN-Hangzhou), P. Li (DE-Ilmenau)

Constrained State and Unknown Input Estimation for Nonlinear Singular Systems Using a URNDDR Approach

The estimation for constrained states in nonlinear singular systems is addressed using a unscented recursive nonlinear dynamic data reconciliation with unknown inputs (URNDDR-UI) approach in this paper. It is well known that the regular unscented recursive nonlinear dynamic data reconciliation (URNDDR) approach can reliably and accurately estimate the nonlinear states with bounds and other constraints, which are quite common in the chemical processes. However, when there are arbitrary unknown inputs (e.g., the deterministic disturbances which cannot be regarded as stable white noises) presented in the model equations, the regular URNDDR fails to cope with this case. In this regard, the recursive weighted least squares estimation (WLSE) is used in combination with the unscented transformation (UT) and nonlinear optimization (NO) methods to formulate the proposed URNDDR-UI approach whose major advantage is its capability of simultaneously estimating constrained states and unknown inputs in the model equations of singular systems. Simulation results demonstrate the efficiency of the proposed URNDDR-UI and indicate its potential of applications to chemical processes.

3:30 p.m.	I. Mynttinen, P. Li (DE-Ilmenau)

Reformulation methods for a hybrid parameter estimation problem
In many industrial processes switching behaviors through changes of the operating mode can occur due to external control actions as well as internal phase transitions which complicate the prediction of system output states from input states. For discontinuous nonlinear dynamic systems the relationship between input and output is not readily accessible for optimization, since discontinuities in the states and their gradients lead to difficulties for finding a solution. This is generally due to the violation of constraints. In this contribution we compare two reformulation methods which lead to a smooth representation of the problem. Discontinuities are removed by introducing a penalty term into the objective function or by replacing the instantaneous transition by a smoothing function in the model equations, respectively. The parameter estimation problem for a three-tank system with internal mode switching behaviors is taken to investigate the effectiveness of both methods. We first present the way how the original problem is modified in both cases. Then the model is implemented in Modelica and included in the optimization framework using JModelica. The parameter estimation problem is solved by the NLP-solver Ipopt. The discretization of the continuous model formulation is carried out using collocation on finite elements. For each method the dependence of the solution on the respective reformulation parameter is investigated. Solutions with appropriate reformulation parameters from both methods are compared and their suitability is discussed.

End of Lecture Session