CAPITOLUL 8

Diseminarea finala a rezultatelor proiectului – Obiectivul IX

Activitatea IX.1:

Finalizarea paginii web a proiectului si realizarea unui CD cu rezultatele proiectului.

Adresa paginii web a proiectului este www.apepur.ugal.ro.

Activitatea IX.2:

Propunerea de lucrari stiintifice in reviste si la conferinte de prestigiu in domeniu.

Au fost publicate 13 lucrari stiintifice in reviste si in volumele unor conferinte de prestigiu, dupa cum urmeaza: 4 lucrari in reviste (o revista ISI – Revista de Chimie si 3 indexate in baze de date internationale), 9 lucrari prezentate la conferinte (7 fiind indexate in baze de date internationale).

Lista lucrărilor

1. Selişteanu D., Petre E., Popescu D., Bobaşu E., 2008, *Nonlinear Control Strategies for Bioprocesses: Sliding Mode Control versus Vibrational Control*, in: Automation and Robotics (J. M. Ramos Arreguin Ed.), I-Tech Education and Publication, Vienna, Austria, pp. 201-222, ISBN 978-3-902613-41-7.
2. Petre E., Selişteanu D., Şendrescu D., Ionete C., 2008, Nonlinear and Neural Networks Based Adaptive Control for a Wastewater Treatment Bioprocess, invited paper, *12th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems - KES2008*, 3-5 Sept. 2008, Zagreb, Croatia, Springer Verlag, in printing [IEEE Xplore, INSPEC].
3. Petre E., Selişteanu D., Şendrescu D., 2008, Adaptive Control Strategies for a Class of Anaerobic Depollution Bioprocesses, *Proceedings of Int. Conf. on Automation, Quality and Testing, Robotics AQTR 2008 (THETA 16)*, May 22-25, 2008, Cluj-Napoca, Romania, Tome II, pp. 159-164, ISBN 978-1-4244-2576-1 [IEEE Xplore, INSPEC].
4. Barbu Cristina, Constantinescu M., Popescu A., Selişteanu D., Preda A., 2008, Study of the Concentrations of the Heavy Metals from the Jiu River, in Post Communist Romania, Journal of Environmental Protection and Ecology, book 3, vol. 9, acceptată pentru publicare, ISSN: 1311-5065 [ISI – Web of Science].
5. Petre E., Bobaşu E., 2008, A new adaptive control strategy for a class of anaerobic wastewater treatment bioprocess, *4th IASME/WSEAS International Conference on*

Energy, Environment, Ecosystems and Sustainable Development (EEESD'08), pp. 303-308, Algarve, Portugal, June 11-13, ISBN: 978-960-6766-71-8, ISSN: 1790-5059. [ISI Proc., INSPEC].

6. Barbu Cristina, Popescu A., Selişteanu D., Preda A., 2008, Determination of the Concentration of Some Toxic Heavy Metals on the Jiu River Course using ICP-MS, *Asian Journal of Chemistry*, Vol. 20, No. 3, pp. 2037-2046, ISSN 0970-7077 [ISI – Web of Science].
7. Selişteanu D., Marin C., Iancu E., 2008, Nonlinear Control and Identification of an Aerobic Fermentation Depollution Bioprocess, *4th IASME/WSEAS Int. Conf. on Energy, Ecosystems and Sustainable Development (EEESD'08)*, ISBN 978-960-6766-71-8, pp. 309-314, June 11-13, 2008, Algarve, Portugal. [ISI Proc., INSPEC].
8. Şendrescu D., Marin C., Petre E., Selişteanu D., 2008, Identification of Nonlinear Hammerstein Models, 9th *Int. Carpathian Control Conference ICCC 2007*, May 24-27, Sinaia, Romania, pp. 599-602, ISBN 978-973-746-897-0.
9. Şendrescu D., Popescu D., Ionete C., Roman M., 2008, Neural Networks Identification of Wastewater Biodegradation Process, *4th IASME/WSEAS Int. Conf. on Energy, Ecosystems and Sustainable Development (EEESD'08)*, ISBN 978-960-6766-71-8, pp. 298-302, June 11-13, 2008, Algarve, Portugal. [ISI Proc., INSPEC].
10. Caraman S., Barbu M., The Design of a Biological Wastewater Treatment Plant Controlled by the Process Computer, Proceedings of the 8th International Conference on Technical Informatics – CONTI'2008, First Workshop on New Directions in Real-Time Networked Control Systems, Timisoara 5-6 Iunie, 2008, Vol. 3, pp. 71-76, Ed. Politehnica, ISSN 1844-539X.
11. Caraman S., Barbu M., The Identification and Robust Control of a Biological Wastewater Treatment Process, Proceedings of IEEE International Conference on Automation, Quality, Testings and Robotics, AQTR'2008, Cluj-Napoca 22-25 Mai 2008, Vol. III, pp. 37-42, ISBN 978-1-4244-2576-1.
12. Caraman S., Bahrim G., Barbu M., Arinton E., Palele M., Ifrim G., Roman N., Liga V., Manole B., Imbunatatirea indicatorilor calitativi la tratarea biologica a apelor reziduale din industria alimentara pe baza unor sisteme de conducere avansata, Conferinta MENER, Sinaia 4-7 Septembrie 2008, lucrare acceptata pentru prezentare si publicare.
13. Barbu M., Caraman S., Ceanga E., Conducerea optimala a procesului de biosinteza a alfaamilazei cu microorganismul *Bacillus subtilis* utilizand un model zonal de tip fuzzy, Lucrare acceptata pentru publicare in Revista de Chimie.

1. Nonlinear Control Strategies for Bioprocesses: Sliding Mode Control Versus Vibrational Control

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Abstract: Nowadays, the domain of biotechnology is characterized by rapid changes in terms of novelty and by highly complex processes that require advanced procedures for design, operation and control. From the engineering point of view, the control of bioprocesses poses a number of challenging problems. These problems arise from the presence of living organisms, the high complexity of the interactions between the micro-organisms, as well as the high complexity of the metabolic reactions. Moreover, for monitoring and control applications, only a few measurements are available, either because the measuring devices do not exist or are too expensive, or because the available devices do not give reliable measurements. Therefore, we can deduce that the main difficulties arising in the control of bioprocesses arrive from two main sources: the process complexity and the difficulty to have reliable measurements of bioprocess variables. In order to overcome these difficulties several strategies for the control of bioprocesses were developed, such as adaptive approach, vibrational control, sliding mode control, fuzzy and neural strategies etc. Sliding mode control (SMC) has been widely accepted as an efficient method for control of uncertain nonlinear systems. The classical applications of SMC (such as robotics, electrical machines etc.) were extended to SMC of chemical processes and to SMC of bioprocesses. The well-known advantages of the SMC are the robustness, controller order reduction, disturbance rejection, and insensitivity to parameter variations. The main disadvantage of the SMC strategies used in real applications remains the chattering phenomenon, even if some techniques of chattering reduction were developed. Vibrational control (VC) is a non-classical open-loop control method. Applications of the vibrational control theory can be found for: stabilization of plasma, lasers, chemical reactors, biotechnological processes etc. The VC technique is applied by oscillating an accessible system component at low amplitude and high frequency. Therefore, this technique can be considered, like the SMC, a form of high frequency control (obviously high-frequency relative to the natural frequency of the system). But, unlike the SMC, the amplitude and the frequency of the control input are constants and independent of the state of the system, so this technique is a form of open-loop control. In this chapter, two nonlinear control strategies for bioprocesses are designed: a feedback SMC law and a vibrational control strategy. First, a class of bioprocesses is briefly analysed and a nonlinear prototype model are present in detail. Then, the design of a feedback control law for a prototype bioprocess is developed. The design is based on a combination between exactly linearization, sliding mode control, and generalized observability canonical forms. In order to implement this SMC law, asymptotic observers will be used for the reconstruction of unmeasured states. The next paragraph deals with the presentation of most important results of vibrational control theory. Also, a VC strategy for a continuous bioprocess is developed. The existence and the choice of stabilizing vibrations, which ensure the desired behaviour of the bioprocess are analysed. Some simulations results, comparisons of the proposed nonlinear control strategies, and final remarks are also presented.

2. Nonlinear and Neural Networks Based Adaptive Control for a Wastewater Treatment Bioprocess

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Abstract. The paper studies the design and analysis of some nonlinear and neural adaptive control strategies for a wastewater treatment process, which is an activated sludge process with nonlinear, time varying and not exactly known kinetics. In fact, an adaptive controller based on a dynamical neural network used as a model of the unknown plant is developed and then is compared with a classical linearizing controller. The neural controller design is achieved by using an input-output feedback linearization technique.

3. Adaptive Control Strategies for a Class of Anaerobic Depollution Bioprocesses

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Abstract-This paper presents the design and the analysis of some nonlinear adaptive control strategies for a class of anaerobic depollution processes that are carried out in continuous stirred tank bioreactors. The controller design is based on the input-output linearization technique. The adaptive control structure is based on the nonlinear model of the process and is combined with a state observer and a parameter estimator which play the role of the software sensors for the on-line estimation of biological states and parameter variables of interest of the bioprocess. The resulted control methods are applied in depollution control problem in the case of the anaerobic digestion bioprocess for which dynamical kinetics are strongly nonlinear and not exactly known, and not all the state variables are measurable. The effectiveness and performance of both estimation and control algorithms are illustrated by simulation results.

4. Study of the Concentrations of the Heavy Metals from the Jiu River, in Post Communist Romania

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Abstract: The Jiu River is an important river from Romania which length is 339 km. Administrative, Jiu hydrographical area/river basin covers integral the counties: Dolj, Gorj, Mehedinti and partial the counties: Hunedoara. Heavy metals represent one the most important categories of pollutants of natural water. Heavy metals produce their toxicity by forming complexes with organic compounds. Small amounts of metallic pollutants can cause extreme damages of environment quality. All metals can produce toxicity when ingested in sufficient quantities, but there are several which are especially important because either they are so pervasive, or produce toxicity at such low concentration.

5. A New Adaptive Control Strategy for a Class of Anaerobic Wastewater Treatment Bioprocesses

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Abstract: - This paper presents the design and the analysis of some nonlinear adaptive control strategies for a class of anaerobic depollution bioprocesses that are carried out in continuous stirred tank bioreactors. The adaptive control structure is based on the nonlinear model of the process and is achieved by combining a linearizing control law with a new state observer and a parameter estimator which play the role of the software sensors for the on-line estimation of biological states and parameter variables of interest of the bioprocess. The effectiveness and performance of both estimation and control algorithms are illustrated by simulation results applied in the case of an anaerobic wastewater treatment bioprocess for which dynamical kinetics are strongly nonlinear and not exactly known, and not all the state variables are measurable.

6. Determination of Toxic Heavy Metals Present in Jiu River Water using ICP-MS

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Abstract: Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. As trace elements, some heavy metals (copper, zinc, selenium), are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metals poisoning could result from drinking-water contamination (for instance, lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. This paper presents a study of some of the toxic heavy metals distribution on the Jiu river course, an important river in Romania. The most pollutants heavy metals from Jiu river course are lead, mercury and arsenic. The concentration of metals was determined by inductively coupled plasma mass spectrometry.

7. Nonlinear Control and Identification of an Aerobic Fermentation Depollution Bioprocess

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Abstract: - The paper deals with the design of nonlinear control laws for an aerobic fermentation depollution bioprocess. This wastewater treatment bioprocess is in fact an activated sludge process that is carried out in a recycle bioreactor. The multivariable nonlinear control law design is achieved by using the input-output linearization technique; consequently, an exact linearizing controller is obtained. The dynamical kinetics of the bioprocess is strongly nonlinear and not exactly known; therefore a high gain observer is developed in order to provide on-line estimates of the unknown parameters. Because some of state variables of the process cannot be on-line measured, an asymptotic observer is used for

state reconstruction. By combining the exact linearizing control law, the high gain adaptation law and the asymptotic observer, an adaptive controller is implemented. Numerical simulations are included in order to test the performance of the proposed control strategies.

8. Identification of Nonlinear Hammerstein Models

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Abstract: The theoretical and experimental study on nonlinear modelling and identification of a electro-mechanical system with a DC motor rotating in two directions is presented in the present paper. Nonlinear model was developed for this system. The nonlinear Coulomb friction and dead zone effects were taken into account, and a nonlinear representation and identification approach using the nonlinear Hammerstein system structure was used for the present system. A suitable experimental setup was built and tested using the recursive least squares identification algorithm for the nonlinear case. The results are numerically and graphically demonstrated.

9. Neural Networks Identification of Wastewater Biodegradation Process

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Abstract: - In this paper we present an algorithm for nonlinear continuous-time model of wastewater biodegradation process identification based on neural networks. The mathematical model of the nonlinear system of wastewater biodegradation process is developed. The topology of the neural network used for identification is presented. The described network is used to identify the wastewater biodegradation process where the unknown parameters appear in rational relations with measured variables. Some simulation results are presented.

10. The Design of a Biological Wastewater Treatment Plant Controlled by the Process Computer

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Abstract: - This paper deals with the design of a wastewater treatment plant totally controlled by the computer. It is designed aiming to improve the biological treatment indicators of the wastewaters from food industry on the basis of advanced control methods. The paper presents the control equipment and the real-time control software developed within our department.

11. The Identification and Robust Control of a Biological Wastewater Treatment Process

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Abstract: - This paper deals with the identification and robust control of a biological wastewater treatment process. The identification has been done on the basis of the minimization of an Euclidian-distance criterion, with respect to the model coefficients. The robust control of the biological wastewater treatment process has been accomplished through QFT (Quantitative Feedback Theory) techniques. To this end three functioning points were defined: *Big_Flow*, *Small_Flow* and *Medium*_Flow. The process has been linearized in the three functioning points. For every linear model a robust controller was designed using QFT robust designing techniques. The overall controller has the same structure with the controllers obtained before. Its parameters are determined by fuzzy aggregation the parameters of the three controllers. The parameter aggregation takes into account the membership degree of the current functioning point to the one or maximum two functioning points defined before.

12. ÎMBUNĂTĂŢIREA INDICATORILOR CALITATIVI LA TRATAREA BIOLOGICĂ A APELOR REZIDUALE DIN INDUSTRIA

ALIMENTARĂ PE BAZA UNOR SISTEME DE CONDUCERE AVANSATĂ

Prof.univ.dr.ing. Sergiu CARAMAN[1], Prof. univ.dr.ing. Gabriela BAHRIM[2], S. l. dr. ing. Marian BARBU[3], Drd. ing. Eugen ARINTON[4], Drd. biolog Mihaela PALELE[5], Msc. ing. George IFRIM[6], C. st. II ing. Nicu ROMAN[7], ing. Viorel LIGA[8], ing. Bogdan MANOLE[9]

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Abstract: - În lucrare sunt prezentate rezultatele ştiinţifice obţinute în cadrul grantului CEEX-MENER, Nr. 717/2006 – APEPUR. Principalul obiectiv obiectiv urmărit în cadrul grantului a constat în îmbunătăţirea indicatorilor calitativi ai apelor uzate din industria alimentară (în special din industria laptelui şi a berii) utilizând metode de automatică (modelare, estimare stare şi parametrii, control automat). Studiile au fost realizate atât în regim de simulare numerică, cât şi prin experimentare pe procese reale. În acest scop, a fost creat laboratorul de epurare ape uzate, cu o dotare corespunzătoare obiectivului urmărit. Principalul echipament realizat în laborator este o staţie pilot pentru epurarea apelor uzate, staţie condusă integral cu calculatorul de proces. Această staţie pilot, proiectată pentru un debit de epurare nominal de 1litru/oră, a permis realizarea studiilor şi experimentelor din cadrul proiectului(www.apepur.ugal.ro).

13. Conducerea optimală a procesului de biosinteză a alfa-amilazei cu microorganismul *Bacillus subtilis* utilizand un model zonal de tip fuzzy

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Abstract: - Aceasta lucrare trateaza modelarea zonala a proceselor de biosinteza care se desfasoara in bioreactoare discontinue. Se utilizeaza tehnici fuzzy in vederea obtinerii unui

model general valabil, indiferent de conditiile de fuinctionare ale bioreactorului. Utilizand modelul fuzzy zonal a fost implementat un algoritm de determinare a momentului de oprire a sarjei astfel incat sa fie indeplinit un criteriu optimal de cost. Modelul fuzzy zonal si algoritmul optimal au fost validate folosind date experimentale pentru procesul de biosinteza a alfa-amilazei cu microroganismul Bacillus subtilis oferite de Institutul de Chimie Alimentara Bucuresti.

Activitatea IX.3:

Organizarea unui workshop final (Galati) pentru prezentarea rezultatelor proiectului.

In Universitatea “Dunarea de Jos” din Galati s-a desfasurat un workshop de prezentare a rezultatelor finale obtinute in cadrul grantului Nr. 717.2006, cu titlul **ÎMBUNATATIREA INDICATORILOR CALITATIVI LA TRATAREA BIOLOGICA A APELOR REZIDUALE DIN INDUSTRIA ALIMENTARA PE BAZA UNOR SISTEME DE CONDUCERE AVANSATA** – Acronim APEPUR. Au fost, deasemenea, prezentate cele doua laboratoare realizate in cadrul grantului, si anume: laboratorul E003 – laborator pentru epurarea biologica a apelor uzate si laboratorul E002 – destinat prelucrarii datelor experimentale (punct de lucru pentru masteranzi si doctoranzi implicati in domeniul epurarii apelor reziduale. La aceasta intalnire au participat specialisti din mediul universitar, de la Agentia de Protectie a Mediului Galati, Fabrica de bere Martens Galati, Galacta SA Galati, Intreprinderea Apa-Canal SA Galati, Institutul de cercetari piscicole Galati etc. Workshop-ul s-a desfasurat in data de 3.09.2008, programul acestuia fiind prezentat in continuare.

Program workshop Grant CEEX-MENER Nr. 717/24.07.2006

15^{30} – Primirea participantilor

16^{00} – Prezentare generala a grantului: Tema. Parteneri. Obiective si activitati (sala E211).

Prezinta coordonator proiect: Prof. Dr. Ing. Sergiu Caraman (Univ. Dunarea de Jos” din Galati)

16^{10} – Prezentarea practica a functionalitatii statiei pilot de epurare biologica. Sistemul de conducere: hardware si software (sala E211).

Prezinta coordonator proiect: Prof. Dr. Ing. Sergiu Caraman (Univ. Dunarea de Jos” din Galati)

16^{30} – Studiul speciilor de microorganisme din punct de vedere al reducerii substantelor organice din apele reziduale din industria alimentara. Testarea acestora pe substraturi model si pe substraturi reale (sala E211).

Prezinta Prof. dr. ing. Gabriela Bahrim (Univ. Dunarea de Jos” din Galati)

16^{45} – Metode de control liniarizant (adaptiv) si vibrational aplicate in conducerea proceselor de epurare biologica. Studiu realizat in regim de simulare numerica (sala E211).

Prezinta S.I. dr. ing. Dorin Sendrescu (Univ. Din Craiova)

17^{00} – Tehnici de identificare si control implementate pe statia pilot de epurare proiectata in cadrul grantului (sala E211).

Prezinta S.I. dr. ing. Marian Barbu (Univ. Dunarea de Jos” din Galati)

17^{15} – Discutii libere pe marginea prezentarilor

17^{30} – Vizitarea laboratorului de epurare alpe uzate si a laboratorului de prelucrare date (punct de lucru pentru masteranzi si doctoranzi) (salile E002 si E003).

Data desfasurarii workshop-ului: 3.09.2008

Locatie:

Univ. „Dunarea de Jos” din Galati, Facultatea de Stiinta si Ingineria Alimentelor, Corp E.

In continuare, se prezinta lista participantilor la workshop-ul de prezentare a rezultatelor obtinute in cadrul grantului Nr. 717.2006, cu titlul **ÎMBUNATATIREA INDICATORILOR CALITATIVI LA TRATAREA BIOLOGICA A APELOR REZIDUALE DIN INDUSTRIA ALIMENTARA PE BAZA UNOR SISTEME DE CONDUCERE AVANSATA** – Acronim APEPUR.