

UNIVERSITY OF CRAIOVA

Programme: *Partnerships in Priority Domains, Applied research collaborative projects*

UEFISCDI Project code: PN-II-PT-PCCA-2013-4-0544

Title of the project: *Advanced control systems for bioprocesses in food industry (ADCOSBIO)*

Contract no.: 211/2014

Period: 01.07.2014-31.09.2017

REPORT OF ACTIVITY - Synthesis -

Phase IV / 2017

Implementation, testing and validation of advanced control systems for processes in food industry

The project ADCOSBIO followed the recent research trends in order to apply the research results to bioprocesses in food industry, particularly to bread production and to related wastewater treatment processes. Bioprocess modelling and control can be successfully achieved using interdisciplinary approaches from control engineering, biochemistry, applied mathematics and information technology. The bioprocesses are complex nonlinear systems, characterized by modelling uncertainties, interconnections, delays, and lack of cheap and reliable instrumentation. In the project these interdisciplinary approaches were used to develop advanced monitoring and control systems.

The main research objectives of ADCOSBIO project are as follows:

1. Analysis and modelling of processes in food industry;
2. Development of novel estimation and identification techniques for bioprocesses;
3. Design of advanced control techniques for three classes of bioprocesses;
4. Implementation of advanced control systems for processes in food industry.

Within the fourth phase (final) of the project (IV/2017), several researches from the fourth objective were accomplished. In accordance with the project plan, the following specific research activities were achieved:

Activity IV.1

Implementation, validation and tests for intelligent tuning procedures (iterative tuning, evolutionary optimization-based tuning) for control loops in the frame of bread production processes at partner P1

Obtained results:

- Gain Scheduling (with variable parameters) PID controllers design and tuning (RG-PI-GS); Controller design by using shape coefficients method; Controller design in structures with multiple degrees of freedom; Iterative experiment-based tuning of controllers; Innovative optimal controller tuning method by using evolutionary algorithms (PSO). (Scientific Report)

Activity IV.2

Development and testing of different advanced control techniques for the bread production process (P1)

Obtained results:

- Tests of the control techniques for the bread production process: experimental results for different phases of the technological process.

Activity IV.3

Improvement of the control systems currently implemented at the mill and bread factory (the achievement of an intermediate level control system)

Obtained results. Innovative advanced control systems for food industry processes:

- A DCS (Distributed Control System) hierarchical monitoring and control system for the wheat grinding and bread production process based on numerical controllers, data acquisition and computer system;

- A DCS hierarchical monitoring and control system for the wheat grinding and bread production process based on compact data acquisition and control systems.

Activity IV.4

Implementation and testing of advanced control techniques for the wastewater treatment process at Water treatment plant Calafat

Obtained results. Innovative control solutions for wastewater treatment processes:

- Control solutions by using two treatment lines (water and activated sludge) emulated on BSM2, with the assessment of control performance and the calculus of optimal set points by using the relaxation method;

- An innovative solution as distributed and hierarchized control and information processing system for Water treatment plant Calafat.

Activity IV.5

Dissemination of research results

Obtained results:

- Publishing of two papers in ISI (WoS) indexed journals: *Journal of Chemical Technology and Biotechnology* (Wiley) [Pet17], *Acta Polytechnica Hungarica* [Țen17] and of a paper in a WorldCat indexed journal: *Journal of Food Technology Research* [Sel17];

- Participation with 8 papers at scientific conferences: ICCO 2017 [Con17], [Mar17], [Şen17], EHB 2017 [Alb17], [Tăn17], ISIE 2017 [Hed17], ISEEE 2017 [Luc17] (all IEEE Xplore indexed), and a plenary lecture at IcETRAN 2017 [Pre17].

Publications

- [Alb17] Albu A. From logical inference to decision trees in medical diagnosis, *Proc. 6th IEEE International Conference on E-Health and Bioengineering (EHB 2017)*, Sinaia, Romania, pp. 65-68, 2017. [IEEEXplore]
- [Con17] Constantinescu R.L., Roman M., Selișteanu D. Simplified numerical methods used for the approximations of chaotic solutions of dynamical systems, *Proc. 18th IEEE Int. Carpathian Control Conf. (ICCC 2017)*, Sinaia, Romania, pp. 560-564, 2017. [IEEEXplore]
- [Hed17] Hedrea L.-E., Bojan-Dragoș C.-A., Precup R.-E., Roman R.-C., Petriu E. M., Hedrea C. Tensor product-based model transformation for position control of magnetic levitation systems, *Proc. 26th IEEE International Symposium on Industrial Electronics (ISIE 2017)*, Edinburgh, UK, pp. 1141-1146, 2017. [IEEEXplore]
- [Luc17] Luca L., Ifrim G, Santin I., Vilanova R., Caraman S., Ceangă E., Barbu M. Optimization of the wastewater treatment processes based on the relaxation method, *Proc. 5th Int. Symp. on Electrical and Electronics Eng. (ISEEE2017)*, Galați, Romania, 2017. [IEEEXplore]
- [Mar17] Marin C., Popescu D., Petre E., Roman M. Mathematical modelling of belt drying plants with several temperature zones, *Proc. 18th IEEE International Carpathian Control Conference (ICCC 2017)*, Sinaia, Romania, pp. 64-69, 2017. [IEEEXplore]
- [Pet17] Petre E., Selișteanu D., Roman M. Nonlinear robust adaptive control strategies for a lactic fermentation process, *Journal of Chemical Technology and Biotechnology*, Wiley, Published online, DOI: 10.1002/jctb.5383, 2017. [ISI, Impact factor IF = 3.135]
- [Pre17] Precup R.-E., Preitl S., Bojan-Dragoș C.-A., Rădac M.-B., Szedlak-Stînean A.-I., Hedrea E.-L., Roman R.-C. Technical and non-technical applications of evolving Takagi-Sugeno-Kang fuzzy models, Invited Paper, *Proc. 4th International Conference on Electrical, Electronic and Computing Engineering (IcETRAN 2017)*, Kladovo, Serbia, pp. 1-8, 2017.
- [Sel17] Selișteanu D., Roman M., Șendrescu D. Experimental model validation and control of a lactic fermentation process, *Journal of Food Technology Research*, DOI: 10.18488/journal.58.2017.41.7.15, Vol. 4, No. 1, pp. 7-15, 2017. [WorldCat]
- [Șen17] Șendrescu D., Selișteanu D., Petre E. Nonlinear PID controller for a bacterial growth bioprocess, *Proc. 18th IEEE International Carpathian Control Conference (ICCC 2017)*, Sinaia, Romania, pp. 151-155, 2017. [IEEEXplore]
- [Tăn17] Tănăsoiu I., Albu A. A connectionist model for cerebrovascular accident risk prediction, *Proc. 6th IEEE International Conference on E-Health and Bioengineering (EHB 2017)*, Sinaia, Romania, pp. 45-48, 2017. [IEEEXplore]
- [Țen17] Țenescu A., Precup R.-E., Minculete N. Evolving fuzzy models for automated translation, *Acta Polytechnica Hungarica*, Vol. 14, No. 2, pp. 27-46, 2017. [ISI, IF = 0.745]

Conclusions

The research objectives of the fourth phase of the project were achieved. The research results consist of: practical intelligent tuning procedures of low-cost controllers for primary loops of the industrial processes, development of innovative control systems for food industry processes, proposal of an innovative advanced control solution for wastewater treatment processes. Scientific reports were completed and the research results were disseminated via the publication of scientific papers (2 in ISI indexed journals, 1 in an IDB indexed journal and 8 presented at conferences).