UNIVERSITY OF CRAIOVA

Programme: ***Partenerships in Priority Domains, Applied research collaborative projects***
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Title of the project: ***Advanced control systems for bioprocesses in food industry (ADCOSBIO)***
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UNIVERSITATEA DIN CRAIOVA

REPORT OF ACTIVITY

- Synthesis -

Phase I / 2014
Analysis and development of bioprocess models for food industry and wastewater treatment. Validation and testing of models via simulation

The project ADCOSBIO follows 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 will be 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 first phase of the project (I/2014), several researches from the first and second objectives were achieved, by means of specific research activities, in accordance with the project plan.

Activity I.1

Modelling of yeast fermentation processes via classical, bond graph and qualitative approaches. Modelling of other various fermentation processes from food industry

Obtained results:

- Models of the baker's yeast fermentation process;
- Models of the alcoholic fermentation process;
- Model of an enzymes synthesis process;
- Modelling methodology for bioprocesses from food industry (Scientific report).

Activity I.2

Analysis of wastewater treatment processes (activated sludge). Development of new models of propagation and recycle stream bioprocesses

Obtained results:

- Simplified models of the aerobic activated sludge wastewater treatment process;
- Approximate models for bioprocesses inside propagation bioreactors;
- Model of a bio-electro-chemical wastewater treatment process, with recycle stream;
- Models of wastewater treatment processes (Scientific report).

Activity I.3

Analysis and comparisons of the bioprocess models via simulation, by using the available programming environments: Matlab / Simulink, 20sim

Obtained results:

- Software tools for modelling and simulation of bioprocesses (in Matlab, 20sim, SIMBA environments).

Activity I.4

Data collection and analysis from food industry processes. Analysis methods. Data pre-processing for tests and comparisons

Obtained results:

- Technical documentation for process analysis – technological flows of the industrial processes at partner P1 (Scientific report).

Activity I.5

Novel identification techniques for bioprocesses. Analysis of current methods. Comparisons and case studies

Obtained results:

- Identification techniques for bioprocesses (Scientific report).

Activity I.6

Dissemination of research results

Obtained results:

- Publishing of three papers in ISI (WoS) indexed journals: *Asian Journal of Control* (Wiley) [Pet14a], *Biochemical Engineering Journal* (Elsevier) [Sel14a], *BioMed Research International* [Sel14b];

- Participation with 5 papers at scientific conferences: *ICSTCC 2014 - International Conference on System Theory, Control and Computing*, IEEE Xplore indexed [Luc14], [Pet14b], [Pre14b]; *IEEE Multi-Conference on Systems and Control*, first rank conference of IEEE Control Systems Society, IEEE Xplore and ISI Proc. indexed [Pre14a], and *Workshop of Optimization based Control and Estimation* (with papers submitted to a Springer volume) [Șen14].

Publications

[Luc14] Luca L., Barbu M., Caraman S., „Modelling and performance analysis of an urban wastewater treatment plant", *Proc. of 18th Int. Conf. on System Theory, Control & Computing ICSTCC*, 2014, Romania, pp. 285-290.

[Pet14a] Petre E., Tebbani S., Selişteanu D., „Robust-Adaptive Control Strategies for a Time Delay Bioelectrochemical Process Using Interval Observers", *Asian Journal of Control*, Wiley, 17, (6), pp. 1-12, Nov. 2015, Publ. online Sept. 2014, [Impact factor IF = 1.411].

[Pet14b] Petre E., Selişteanu D., „A Robust-Adaptive Control Strategy for a Continuous Alcoholic Fermentation Process", *Proc. of 18th Int. Conf. System Theory, Control & Computing ICSTCC*, 2014, Romania, pp. 430-435.

[Pre14a] Precup R.E., Petriu E.M., Fedorovici L.O., Rădac M.B., Drăgan F., „Multi-Robot Charged System Search-Based Optimal Path Planning in Static Environments", *Proc. of IEEE Multi-Conf. on Systems & Control, Int. Symp. on Intelligent Control (ISIC)*, 2014, France, pp. 1912-1917.

[Pre14b] Precup R.E., Bota D.C., Dragoş C.A., Stînean A.I., Preitl Ş., Rădac M.B., „Frequency Domain Design of Fractional Order PI Controllers for Lambda Control", *Proc. of 18th Int. Conf. on System Theory, Control & Computing ICSTCC*, 2014, Sinaia, Romania, pp. 658-653.

[Sel14a] Selişteanu D., Tebbani S., Roman M., Petre E., Georgeanu V., „Microbial production of enzymes: Nonlinear state and kinetic reaction rates estimation", *Biochemical Engineering Journal*, Elsevier, 91, pp. 23-36, 2014, [Impact factor IF = 2.368].

[Sel14b] Selişteanu D., Şendrescu D., Georgeanu V., Roman M., „Mammalian cell culture process for monoclonal antibody production: nonlinear modelling and parameter estimation", *BioMed Research International*, 2014, accepted, [Impact factor IF = 2.706].

[Şen14] Şendrescu D., Tebbani S., Selişteanu D., Bioprocesses parameter estimation by heuristic optimization techniques, *2nd Workshop on Optimization based Control and Estimation*, November 2014, SUPELEC, France.

Conclusions

The research objectives from the first phase of the project were achieved. The research results are: models of fermentation processes from food industry and of wastewater treatment bioprocesses, a modelling methodology for bioprocesses, the design of software tools for modelling and simulation, process analysis, and the analysis of identification techniques for bioprocesses. Scientific reports were completed and the research results were disseminated via the publication of scientific papers (three in ISI indexed journals and 5 presented at conferences). By using the results of the first phase, in the next years advanced control techniques for bioprocesses will be developed, in different control system structures. Three main processes are envisaged: bread production, wheat grinding and flour processing, and wastewater treatment.