ENGINEER'S PLAYGROUND: INTERFACING STUDENTS AND BIOREACTORS FOR TEACHING AND RESEARCH

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INTRODUCTION

Young graduates are an important driving force for the fourth industrial revolution. Therefore universities have to incorporate elements such as process simulation, automatization but also big data management in their study programs. Within the biochemical engineering work group E166-4 a web based system was established, which enables the direct accessibility of data from all bioreactors with a Python™and Matlab® programming interface. This eases data evaluation and enables the development and execution of real-time actions such as automatization and control without software limitations. Besides the successful use of the system in applied science, it was also used for lab courses in bioprocess engineering (e.g 166.164 LU Bioverfahrenstechnik) with positive feedback.

THE NEED OF A FLEXIBLE REAL-TIME LABORATORY ENVIRONMENT

Due to the high quality requirements of biopharmaceutical products, production processes are supervised by a growing diversity of sensors and analytical devices. To benefit from this increasing amount of information, data needs to be accessible in a manageable format. Whereas data scientists usually analyse historical datasets to extract knowledge, engineers mostly aim to maintain something under control. Therefore they need real-time access to the collected data and the possibility to act on them in time. Most commercially available devices (reactors, sensors, measurement devices) have a specific application and are limited in their extended use. Beside this, a significant amount of time is invested in data export, manual treatment and collection into data tables for later import into mathematical computing programs such as R, Python™, Matlab® and others, which enable to solve scientific exercises.

Figure 1: Real-time laboratory environment with easy accessible web interface

To overcome these barriers and to support students and researchers to realize their tasks and innovative ideas in a comfortable and efficient way,

a web based system was implemented in TU Wien's biochemical laboratories. The system is able to collect data from any physical device that supports any type of open platform communications (OPC). Through an intuitive web-interface (Django framework), which is shown in Figure 1, data can be visualized directly within the browser and compared to other running or historical processes. That way, running fermentation processes can easily be supervised from everyone, anytime and everywhere. Furthermore, selected data can be sent automatically to a running Matlab console or analysed directly in Jupyter notebooks (an interactive Python computing platform), where advanced algorithms can be implemented and executed. It was already successfully used for control of *Escherichia coli* and *Penicillium chrysogenum* processes and is the basis for further research in the fields of advanced monitoring and control.

INTERNET OF THINGS IN APPLIED TEACHING

Besides the quite obvious usefulness of the system for applied research, it could also be used successfully for teaching. To keep teaching up to date and to show and enable students to work in a digitalized industry, a practical laboratory course with a yeast fermentation process was extended by a modeling and data evaluation part. Now, in addition to learn how to conduct a real fermentation process, students are required to simulate a model [1] implemented in a Jupyter notebook. Furthermore, they have the possibility to simulate and parametrize the model using their recorded process data. Exemplary results can be seen in Figure 2. In this new course participants get first hands on, in working within a digitalized laboratory environment. Furthermore, the work with own data is motivating and helps the students to understand the interlink between modeling, simulations and real process data. Finally the course extension has broaden the view of participants and increased the acceptance to work intensively with data.

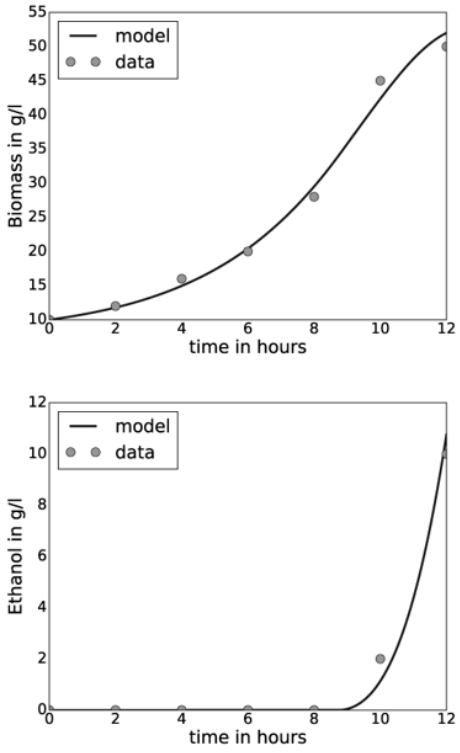

Figure 2: Application example: Model parametrization

CONCLUSION & OUTLOOK

A flexible real-time laboratory environment is an important basis for fruitful research in the field of bioprocess engineering as it enables the realization of innovative ideas. Furthermore, it opens up new perspectives in interactive teaching enabling to bridge offline simulations of models with real data and to bring young graduates closer to the vision of industry 4.0.

REFERENCES

[1] B. Sonnleitner and O. Käppeli. "Growth of *Saccharomyces cerevisiae* is controlled by its limited respiratory capacity: formulation and verification of a hypothesis". In: *Biotechnology and bioengineering* 28.6 (1986), pp. 927-937.