An Educational Bioprocess Simulator (BioVL): Introduction of Disturbances

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Computing and Data Science in ChE Education: In Honor of Fred Justice's Contributions to the Education Division

This session will focus on approaches to incorporating computation, simulation, and data science into the ChE curriculum. Example topics may include teaching process simulation tools such as AspenPlus, ChemCAD, HYSYS; simulation or numerical analysis software such as MATLAB, GROMACS; programming languages such as Python, Fortran, C++, etc. Each software has challenges depending on factors such as the academic level of the students, class size, whether the software is taught standalone or as part of a technical course, as well as whether instruction is done in a classroom setting, in a computer lab, as online-learning, or a combination thereof.

An Educational Bioprocess Simulator (BioVL): Introduction of Disturbances

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Simulators and virtual environments are increasingly used for educational purposes. However, commercial simulators – such as AspenPlus, HYSYS or Pro/II - have several issues in their design and application when deployed in the classroom. One of the key issues for undergraduate students is the sense of loss of reality with regards to the data[1]. This is due to the disparity between the data obtained in the laboratory, which comes with noise and errors; and the results from the solution of a mathematical model inside a computer-aided tool. The lack of variation and reality in the inputs and outputs of the model decreases the motivation of the students[2] and thus, it plays an important role in the user experience for these simulators as educational tools.

In the case of bioprocesses, disturbances do not only come from errors and noise, but also from the fact that we are dealing with living cells, and accordingly, there is intrinsic variation. Therefore, undergraduate students must be aware of the presence of variations inside this kind of processes and educational simulators must represent this reality. In this work, disturbances are implemented in the mechanistic models describing bioprocesses inside the educational software platform (BioVL) developed at the Department of Chemical and Biochemical Engineering of the Technical University of Denmark. BioVL[3] has been designed by integrating: 1) a thoughtful learning design; 2) a motivational approach based on the use of gamification; and, 3) the use of object-oriented modeling together with mechanistic models. The above-mentioned disturbances are based on superposing sinusoidal oscillating perturbations[4] inside the models. Through the linear combination of sine and cosine waves, we are able to introduce generic and time dependent disturbances inside the model. The function implemented produces realistic looking noise that is similar to industrial observations, based on an expert opinion. In the BioVL, the presence, amplitude and frequency of the disturbances are decided by the students and the noise can be removed from the results by clicking in the generated plot.

This open-source software has been developed in Python, where future users - the students - are involved as co-designers. The students have access to some of the mechanistic models and the disturbance function, which are available and explained in a Github repository (https://github.com/simonetacannodelas/BioVL-Library). BioVL is still a prototype and a user experience (UX) is scheduled for the beginning of May, where we will distribute it amongst a pool of students as beta users and co-designers. The results from the survey about the student's perceptions will be presented and addressed. Furthermore, it is the expectation of the authors that the addition of disturbances inside the models is not only valuable from a pedagogical perspective but also for the training of engineers inside production facilities. Hence, this software tool targets the education of undergraduate students in Chemical and Biochemical Engineering; although, it could be used as well for the training of operators and engineers in production in the future.

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