TECHNOLOGY
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Features & Benefits

- A dynamic classification framework which operates in sequential binary manner to increase accuracy phase identification
- Robust classification methods based on machine learning and soft computing techniques
- Avoidance of time- and cost-intensive manual annotation of bio-process phases

Users & Application

- All applications where sensors collect bio process data

Status – our offer

- Expertise for knowledge exchange
- R&D cooperation

Contact data

Edwin Lughofer
Fuzzy-Logic Laboratorium Linz-Hagenberg/Department of Knowledge-Based Mathematical Systems
Johannes Kepler University Linz
edwin.lughofer@jku.at
0043 7236 3343 431

JOHANNES KEPLER UNIVERSITY LINZ

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Industrial Methods for Process Analytical Chemistry

Process-Phase-Identification

A Dynamic Classification Framework for On-line Identification of Bio-Process Profiles

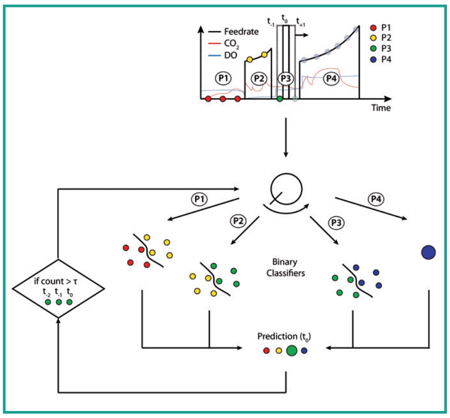
This technology provides a new dynamic classification framework containing various soft computing and machine learning classifiers for sequential classification of bio-process phases. It is able to dynamically learn the phases and their transitions including time lags, and could outperform related state-of-the-art works by a reduction of miss-classification rates by more than 50%.

Background

Bioprocesses are the principal driver for innovation in the pharmaceutical industry as well as for the sustainable production of bio-based chemicals and polymers. However, achieving consistent high product quality, quantity and process safety is particularly challenging for bioprocesses due to the complex interplay between biology and process technology. Data-driven knowledge extraction from historical data has been a key strategy towards a better understanding of (bio-) processes. A pivotal first pre-processing step when analyzing bioprocess data is the segmentation of time profiles into either physiologically meaningful and/or technological feed phases in which microbial populations exhibit a stable, well predictable behavior. Manual annotation of these phases typically needs considerable human effort which is a major bottleneck limiting full exploitation of this resource. Most of the approaches currently available are of pure statistical nature by supervising control charts of the current running process, and do not take into account higher-dimensional input features and imbalanced problems. Moreover, they require a large number of tuning parameters.

Improvement

Our approach improves this situation by offering a dynamic classification framework which contains data-driven classification methods which are built upon the concepts of machine learning and soft computing.
It operates on a sequential manner by automatically recognizing the transitions between two consecutive phases during the on-line process, also respecting a certain lag to actually perform the switch from one phase to the other (see the figure below for its basic functionality).



A dynamic classification framework for identifying bio-process phases sequentially

imPACts – CONSORTIUM MANAGEMENT:
RESEARCH CENTER FOR NON DESTRUCTIVE TESTING GMBH (RECENDT), SCIENCE PARK 2
ALTENBERGER STRASSE 69, 4040 LINZ, AUSTRIA, +43 732 2468-4600
OFFICE@RECENDT.AT, WWW.RECENDT.AT

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The embedded classifier training methods for the sequential binary tasks with specific cost learning functionality are decision trees, support vector machines, a robust version of logistic regression and an own developed fuzzy classifier.

Benefit

Time- and cost-intensive manual annotation of bio-process phases can be avoided. Restrictions of related state-of-the-art works based on statistical process control can be compensated.

Application Example „Escherichia Coli fed-batch fermentation process“

As a representative process for microbial fermentation, our approach was tested for an E. coli fed-batch process with induced production of green fluorescent protein (GFP). The used data set originates from a design of experiment (DoE) series where the influence of different feeding profiles and feeding length on product formation was investigated. Hence, feed profiles display a high degree of variability and are well suited to assess the performance of feed phase classification algorithms. Fed-batch experiments were carried out in a DASGIP multi-bioreactor system consisting of four glass bio-reactors with a working volume of 2l each. All reactors were equipped with baffles and three disk impellers. Typical sensors for in-process control were used.

The amount of dissolved oxygen (DO) was controlled in order to prevent oxygen limitation during aerobic growth. The pH was kept constant at 7.2 and temperature controlled between 30-35 degrees of Celsius. Substrate and base feed- and off-gas analytics including oxygen and carbon dioxide measurements were carried out throughout the process.

Classification results showed extremely good performance by more than 99.5% classification accuracy. Especially for smaller, short-term phases, the new approach could significantly outperform related state-of-the-art works relying on direct multi-class methods.

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