Engineering Tripos Part IIA Project, SG2: Bioreactor Control, 2025-26

Leader

Dr S Bakshi [1]

Timing and Structure

Fridays 11-1pm and Tuesdays 9-11am plus afternoons

Prerequisites

2P6, 3F1 (desirable), 3G1 (desirable)

Aims

The aims of the course are to:

- To gain understanding of the relevant biological processes and process control in bioreactors
- To learn about the operation and calibration of the relevant sensors and actuators for monitoring and maintaining process variables
- To design an experiment to analyse the role of process variables on system performance

Objectives

As specific objectives, by the end of the course students should be able to:

- To develop a virtual bioreactor model for simulating different controllers and associated parameters
- To use and calibrate sensors for cell density and temperature of the cell culture in a microbial bioreactor
- To regulate one environmental variables (e.g. temperature) and cell density for optimising growth of the culture
- To model and experimentally test microbial population growth under nutrient limited conditions at controlled temperature
- To implement and compare performance of open-loop and closed-loop control of cell density to regulate nutrient availability

Content

BACKGROUND:

Bioreactors are the key technology for bioprocess engineering. Primarily, bioreactors are used to keep cells (microbial or mammalian) under controlled conditions such that they can optimally perform the desired tasks. Example application include bioproduction of antibodies and vaccines, tissue engineering, or even nutrient production usign bacteria and algae.

PROJECT:

This project introduces you to some of the essential concepts of the bioprocesses in microbial bioreactors and how to use sensors and actuators for monitoring and controlling the environmental variables to keep those bioprocesses

operating in an efficient manner. You will also learn about sources of noise and drift in such bioprocesses and how closed-loop feedback control can be implemented for maintaining the process variables. You will develop a virtual bioractor which incorporates the relevant processes (preferably in MATLAB) and can enable testing control performance. You will use experimental data to test the model predictions.

The project covers concepts of logistic growth of microbial populations, scattering based measurements of population growth over time and single cell imaging for calibration of such measurements, and how temperature, nutrient density, and oxygen level affect population growth. For process control, the project will cover chemostat and turbidostat modes of culture maintenance.

FORMAT:

Students will work in pairs. Engineers might be paired with medics. There are total 4 lab sessions. Each student will write interim reports by the end of weeks 1, 2, and 3 and a final report by the end of week 4.

ACTIVITIES:

Week 1: Develop and test a temperature regulation simulator for the bioreactor
Week 2: Monitor and model cell growth at regulated temperature
Week 3: Test different cell density regulation strategies at regulated temperature and explain the observed performance differences
Week 4: Develop an integrated simulator for the bioreactor cell density regulation

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

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Links
[1] mailto:sb2330@cam.ac.uk
[2] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations