Optimization of continuous cultures of *Dunaliella tertiolecta* using extremum-seeking

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1 Introduction

Micro-algae cultures in photo-bioreactors have received a regain of interest in the last two decades in view of the multiple potential applications ranging from the production of biofuels to pigments, nutrients and products of pharmaceutical interest. This process industrialization however requires accurate monitoring and control which, from an operational point of view, are necessary to determine optimal feeding strategies (i.e. the time evolution of input and output flow rates) in order to maximize the biomass productivity. Real-time optimization and, in particular, extremum-seeking, is well-adapted to the problem since the approach aims at directly adapting on-line unknown parameters (in this case, the inlet feed rate or, at constant volume, the dilution rate D) in order to reach process optimum, transforming the optimization in a feedback control problem. Model-free bank-of-filter extremum-seeking has been applied successfully to dynamic optimization of a generic continuous bioprocess model in [1], using a gradient descent along a smooth cost function. In the current work, Droop model [2], uncoupling biomass growth and nutrient uptake under constant light, with parameters from [3] for *Dunaliella tertiolecta* is used to test an extremum seeking strategy.

2 Results

The extremum-seeking control algorithm is designed in order to estimate the optimal system input, the dilution rate D^*, maximizing the micro-algal biomass productivity considered as a measurable optimization criterion (system output) of the form:

$$J = D\,X \tag{1}$$

where X represents the micro-algal biomass concentration. As shown in Figure 1, the general strategy applied to *Dunaliella tertiolecta* performs successfully in estimating $D^* \approx 0.84d^{-1}$ and converges with a rather acceptable speed, compared to a realistic cultivation time, to a neighbourhood of the optimum. The strategy appears efficient, robust to model uncertainties (since the method is model-free) and also easily transferable to other strains and culture conditions. Experimental investigations are currently conducted in the BioSys Center laboratories at the University of Mons with flat panel photobioreactors operated in continuous mode, in order to validate this optimization strategy.

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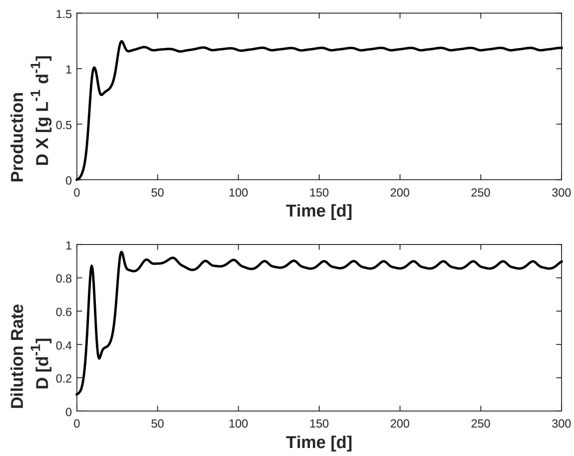

Figure 1: Micro-algae productivity optimization using bank-of-filter extremum-seeking: *Dunaliella tertiolecta* strain