Uncertain Parameter Estimation Batch One-stage CSTR with Nlopt.jl or PolyChaos.jl

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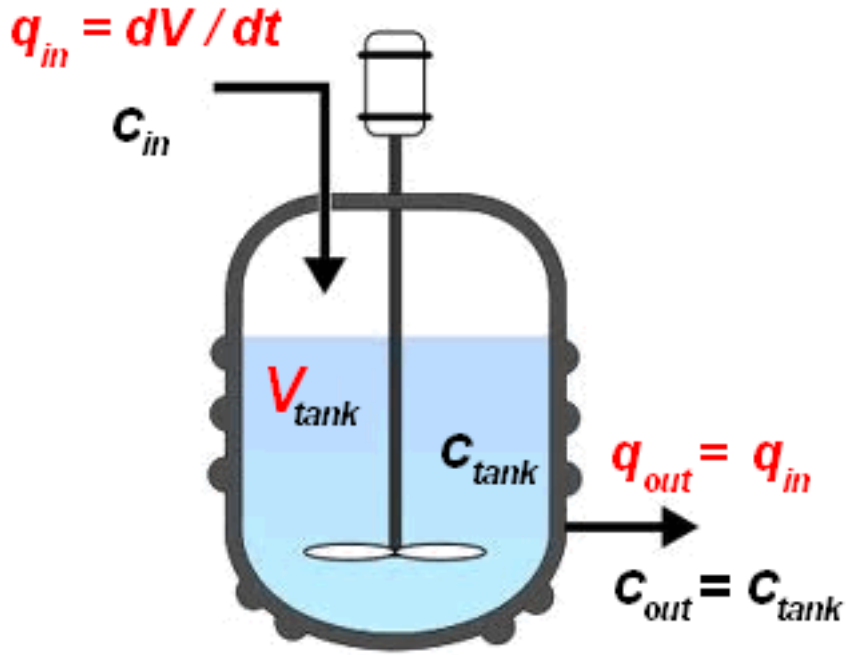
Model

- Given input ‘x(t)’ and output ‘y(t)’ for stochastic non-linear model, find parameters to estimate one-stage CSTR.
- Configure parameters for change in time. In a real-world model, use past and current change in output to configure parameters for state model.
- State estimation of ‘Batch Mode One-stage CSTR’ model provided by Krystian Ganko.

Methodology/Algorithm

- Take arbitrary 't_i' that represents a timepoint at interval where sensors are taken to see cell concentration.
- Send these outputs along with inputs to digital twin to configure existing configured parameters with new data.
- Configuration through error cost function passed through NLopt.jl



$$\frac{\mathrm{d}T}{\mathrm{d}t} = \mu T - k_1(V_\mathrm{s} + V_\mathrm{d})T + D(T_\mathrm{in} - T), \tag{1}$$

$$\frac{\mathrm{d}I_\mathrm{d}}{\mathrm{d}t} = k_1 V_\mathrm{d} T - (k_1 V_\mathrm{s} - \mu) I_\mathrm{d} - D I_\mathrm{d}, \tag{2}$$

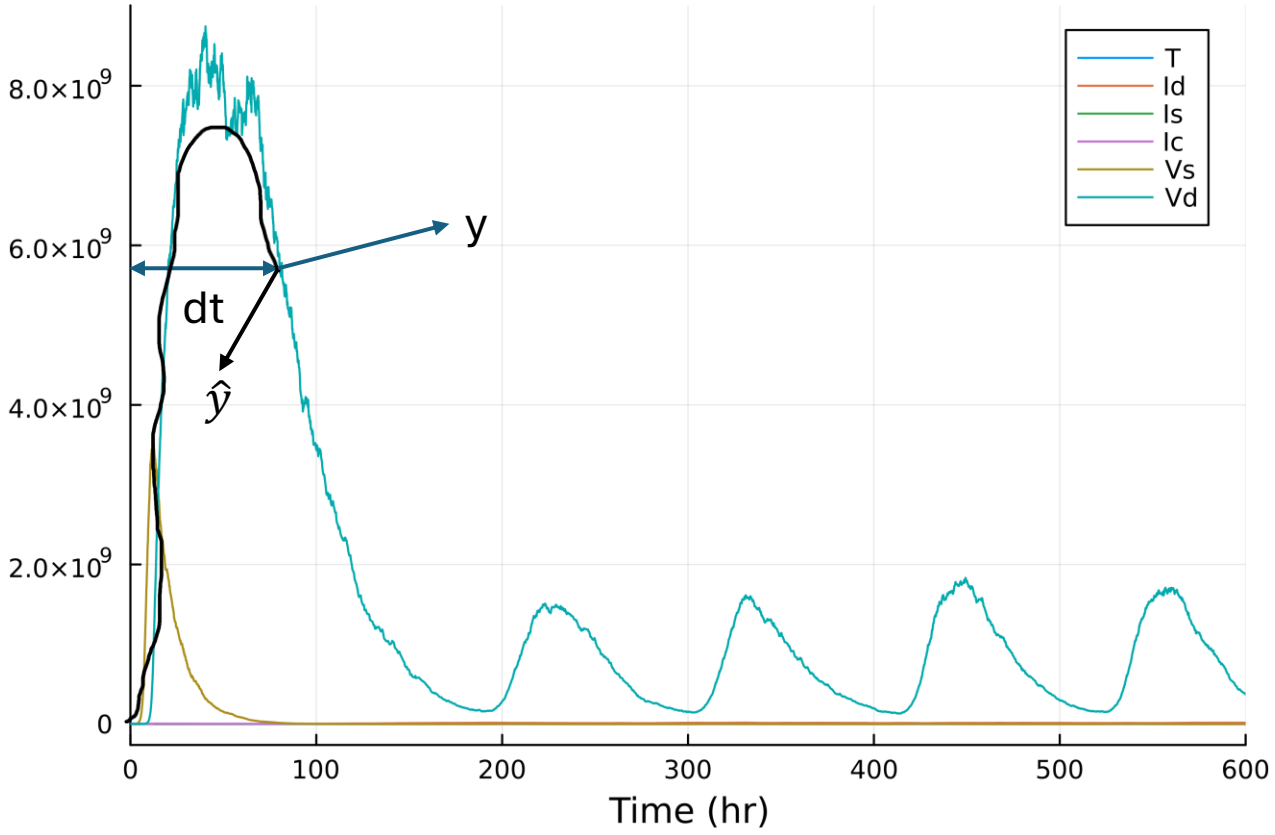
$$\frac{\mathrm{d}I_\mathrm{s}}{\mathrm{d}t} = k_1 V_\mathrm{s} T - (k_1 V_\mathrm{d} + k_2) I_\mathrm{s} - D I_\mathrm{s}, \tag{3}$$

$$\frac{\mathrm{d}I_\mathrm{c}}{\mathrm{d}t} = k_1(V_\mathrm{s} I_\mathrm{d} + V_\mathrm{d} I_\mathrm{s}) - k_2 I_\mathrm{c} - D I_\mathrm{c}, \tag{4}$$

$$\frac{\mathrm{d}V_\mathrm{s}}{\mathrm{d}t} = k_3 I_\mathrm{s} - (k_1(T + I_\mathrm{d} + I_\mathrm{s} + I_\mathrm{c}) + k_4 + D) V_\mathrm{s}, \tag{5}$$

$$\frac{\mathrm{d}V_d}{\mathrm{d}t} = k_{33} I_\mathrm{c} + f k_3 I_\mathrm{s} - (k_1(T + I_\mathrm{d} + I_\mathrm{s} + I_\mathrm{c}) + k_4 + D) V_\mathrm{d}, \tag{6}$$

One-stage CSTR Stochastic Model



At time 't_i', call Discrete Event to optimize parameters at that point.

Find error (cost): $\tilde{y} = y - \hat{y}$

*Optimize parameters for error (cost)

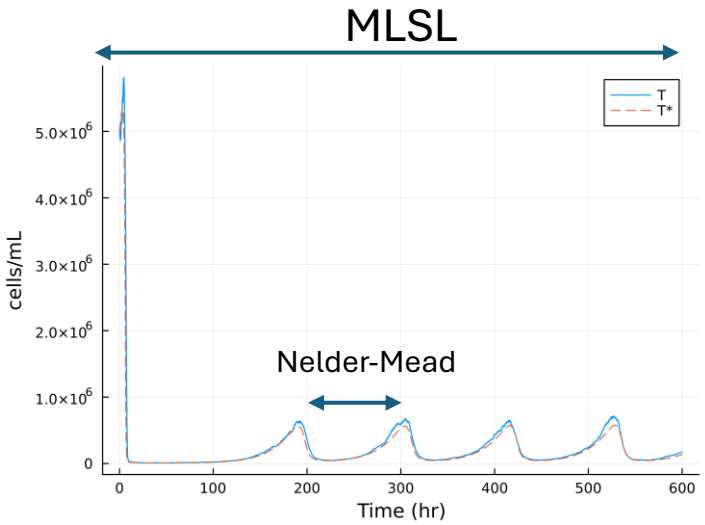
Weight resulting parameters with existing parameters: $P = \phi_{ex}P + \phi_{new}P$

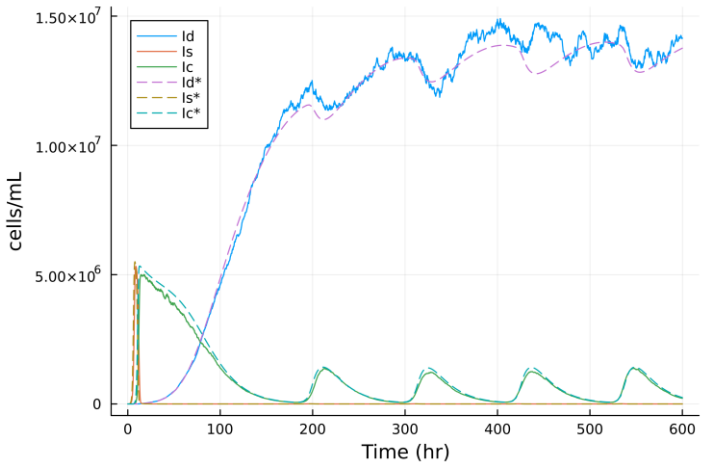
Where ϕ is the weight of the error.

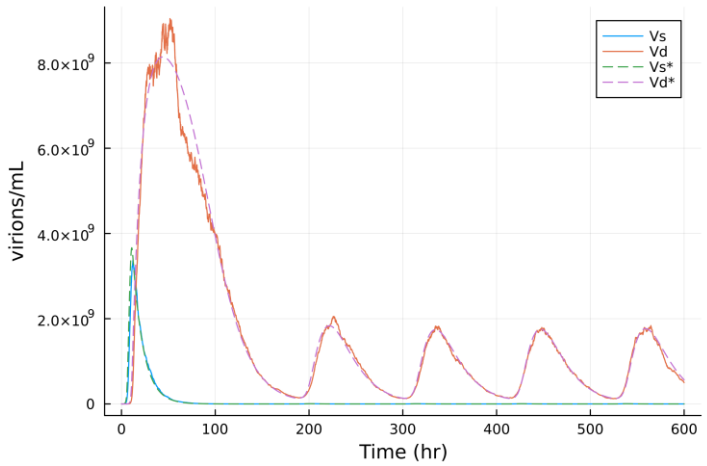
As t -> ∞, |(true value)-(estimated value)| approaches 0 as parameters converge.

NLopt.jl

Findings for Time Span (600 hrs)





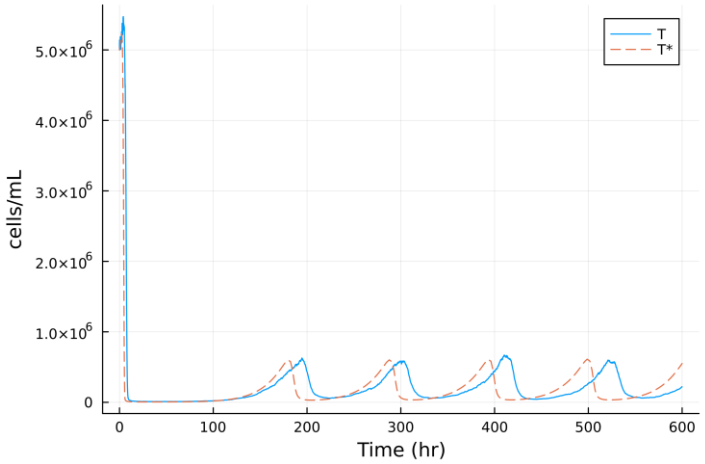


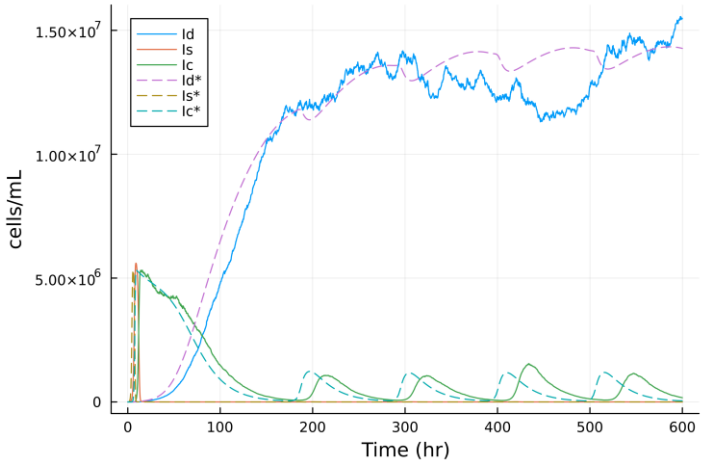
Configured Parameters: [2.30e-9, 0.00869, 135, 147, 0.0320, 26.2]

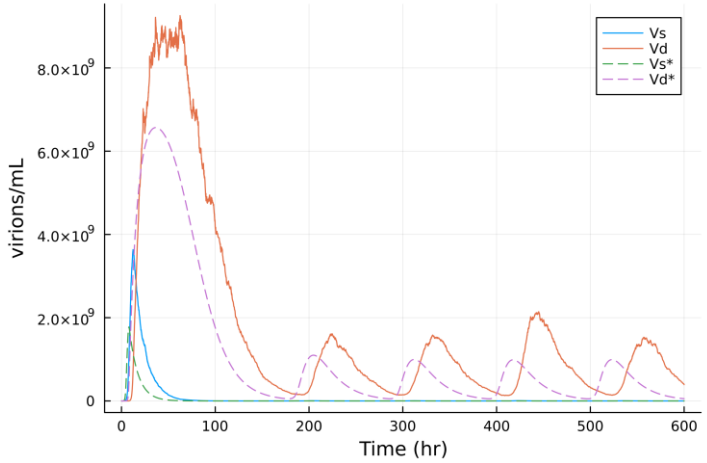
**Sensing interval at 50 hrs, MaxTime set to 30 seconds*
**Runs in ~6 minutes*

**MLSL: Multi-Level Single-Linkage*

Findings for Time Span (600 hrs)







Configured Parameters: [5.79e-9, 0.00451, 131, 152, 0.0369, 2.31e11]

**Sensing interval at 50 hrs, d=6*
**Runs in ~2 minutes*