

# Are complex models required for the control of substrate during cultivation?

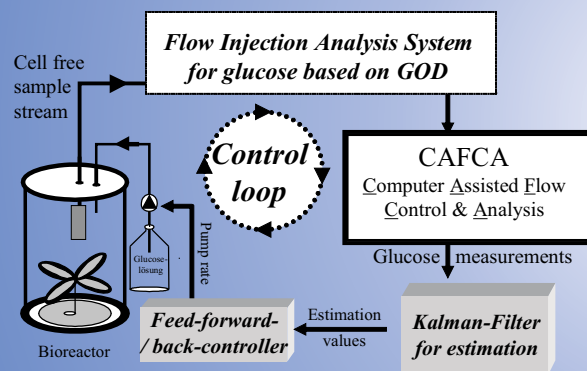
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## 1. The Control Loop with Kalman Filter

### Escherichia coli cultivation



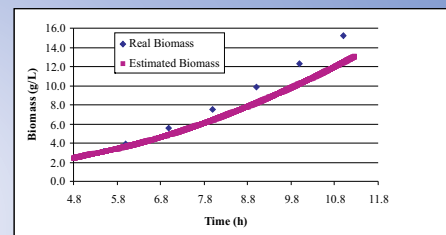
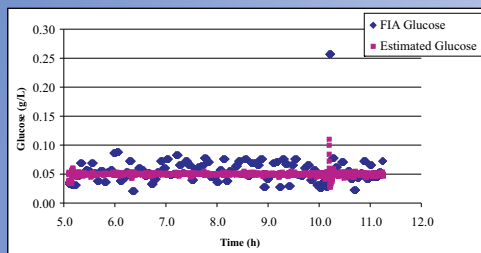
### The model

$$\begin{bmatrix} \frac{dX(t)}{dt} \\ \frac{dS(t)}{dt} \\ \frac{d\mu_{max}(t)}{dt} \\ \frac{dV(t)}{dt} \end{bmatrix} = \begin{bmatrix} \frac{\mu_{max} S(t)}{K_m + S(t)} X(t) - \frac{\dot{V}_f(t)}{V(t)} X(t) \\ -\frac{\mu_{max} S(t)}{K_m + S(t)} X(t) + \frac{\dot{V}_f(t)}{V(t)} (S_0 - S(t)) \\ 0 \\ \dot{V}_f(t) - \dot{V}_{sum} \end{bmatrix} + \begin{bmatrix} u_x \\ u_s \\ u_\mu \\ u_v \end{bmatrix}$$

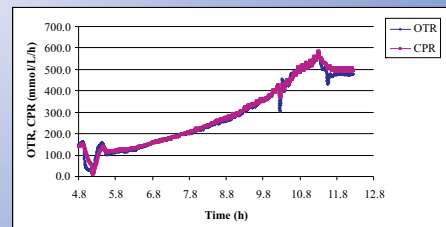
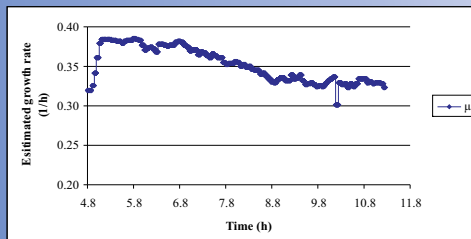
$$\frac{dP(t)}{dt} = F^T(t)P(t) + P(t)F^T(t) + Q$$

$$\hat{V}_f(t_i) = \hat{V}(t) \frac{\hat{\mu}_{max}(t_i) \hat{S}(t_i) \hat{X}(t_i)}{Y_{X/S} [K_m + \hat{S}(t_i)] [S_0 - \hat{S}(t_i)]} + \hat{V}_{PI}(t_i)$$

## 2. The Results



Glucose set point 0.05 g/L



## 3. Conclusions

Mean measured glucose concentration 0.0562 g/L  
Standard deviation 0.025 g/L  
Growth rate is in the range of 0.3 h<sup>-1</sup> to 0.4 h<sup>-1</sup>



Control was successful!  
Monod model seems not to be valid.