GENERAL DYNAMICAL MODEL APPROACH FOR GLUCONIC ACID PRIDUCTION

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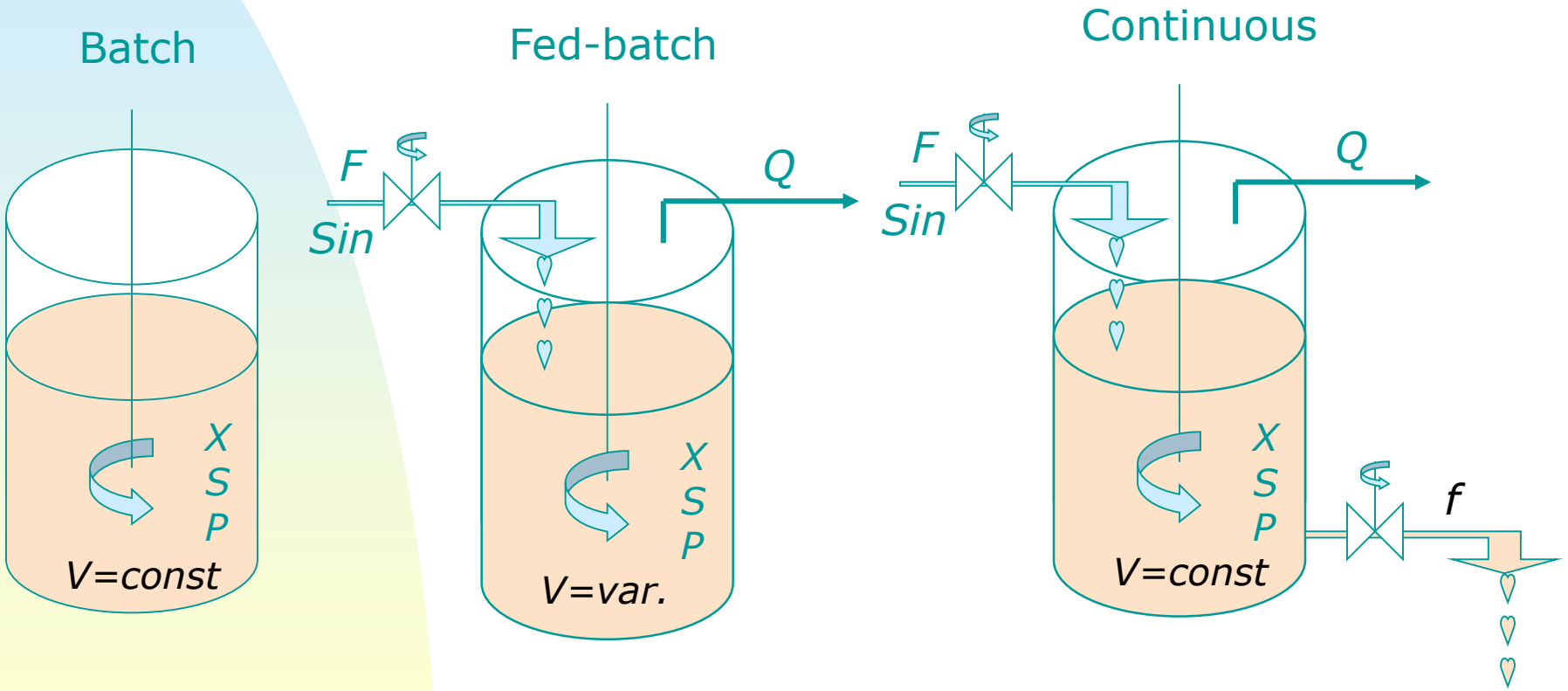
MODES OF CULTIVATION



INTERCONNECTION SCHEME

Expert knowledge

On-line and laboratory measurements

Biotechnological models derivation

Process data bases

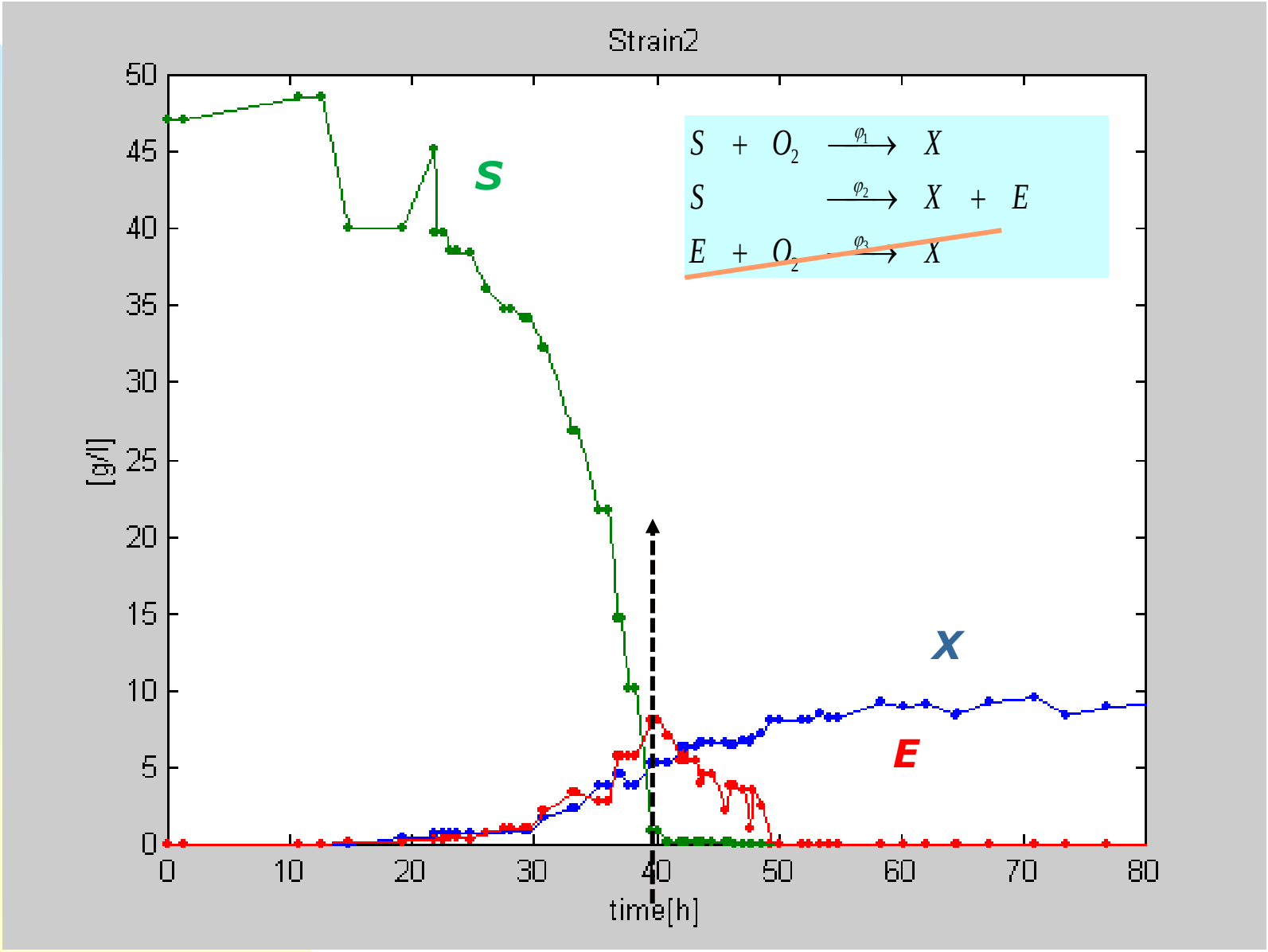
Models for control derivation

Software sensors design

Control algorithm design

InSEMCoBio

BATCH EXPERIMENTAL DATA OF YEAST FERMENTATION



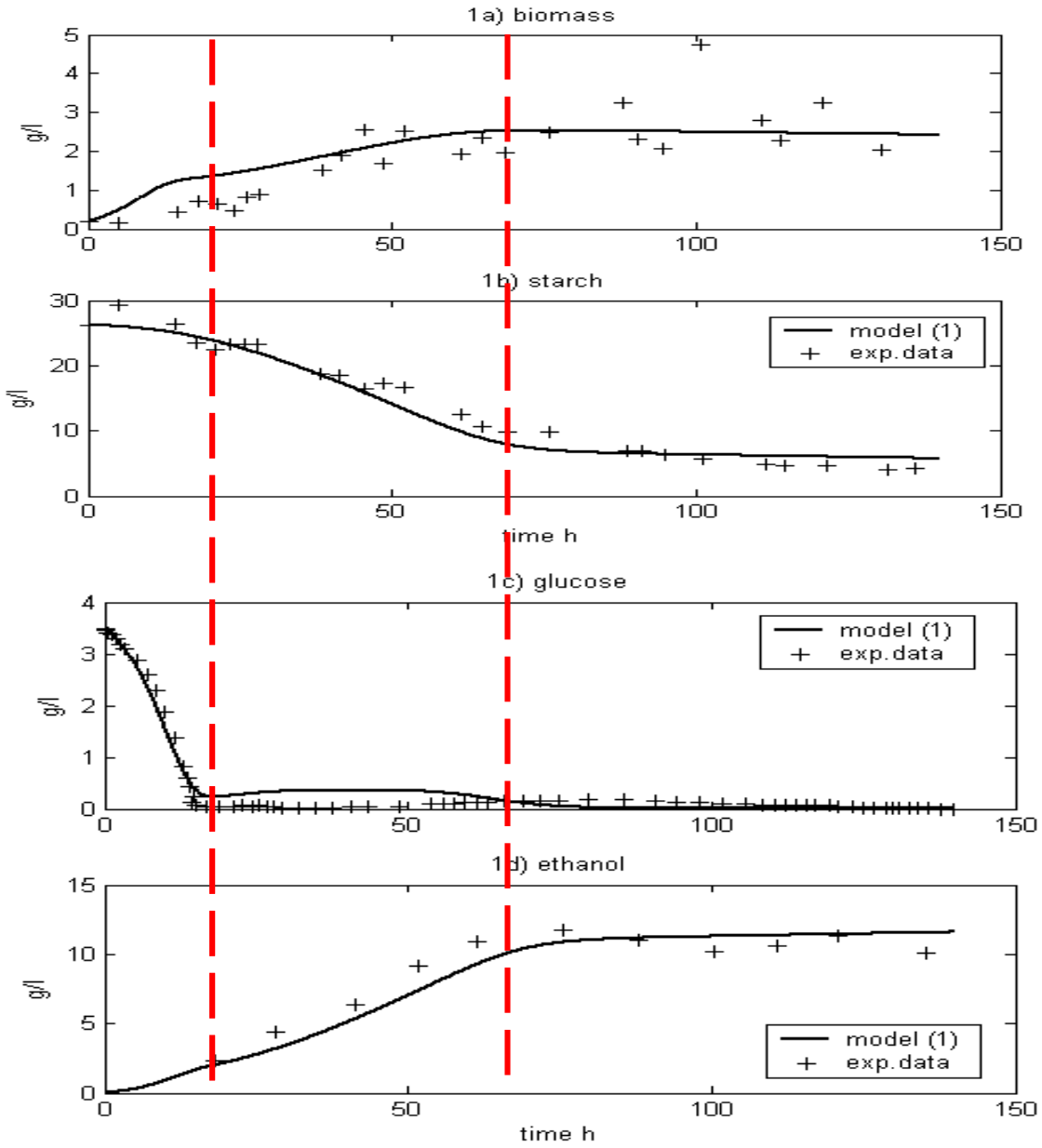
Simultaneous saccharification and fermentation of starch to ethanol (SSFSE) – Experimental data

Схема на реакциите

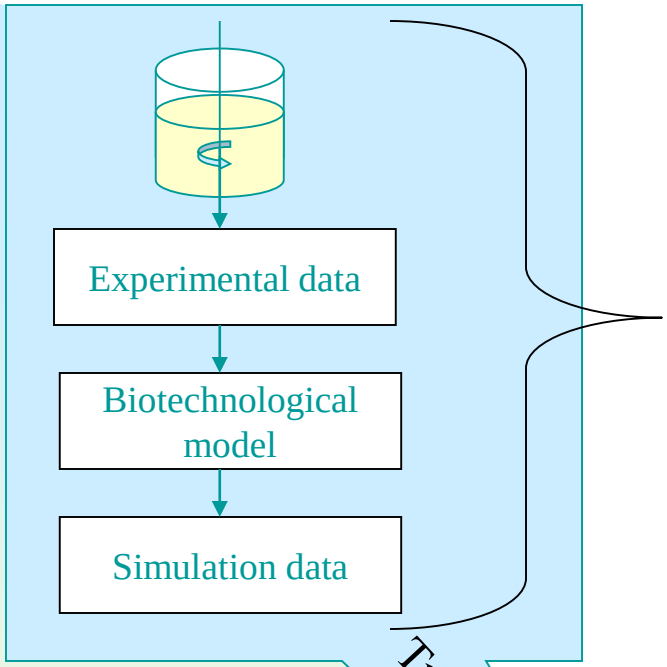
$$S \xrightarrow{\varphi_1} G$$

$$G \xrightarrow{\varphi_2} X + Enz$$

$$G \xrightarrow{\varphi_3} E$$



MODEL-BASED CONTROL



AVAILABLE process information

Translation

Operational model

Appropriate inputs

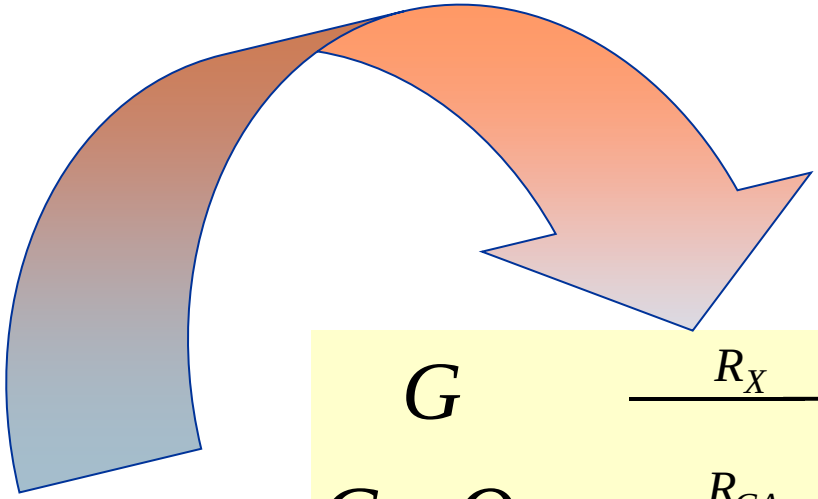
for

Linear control theory

REACTION SCHEME FOR GLUCONIC ACID PRODUCTION

Glucoholactone (*GOT*)

Hydrogen peroxide (H_2O_2)



$$G \xrightarrow{R_X} X$$

$$G + O_2 \xrightarrow{R_{GA}} GA$$

$$G \xrightarrow{R_X} X$$

$$G + O_2 \xrightarrow{R_{GOT}} GOT + H_2O_2$$

$$GOT + H_2O \xrightarrow{R_{GA}} GA$$

$$H_2O_2 \xrightarrow{R^{decom}_{H_2O_2}} H_2O + \frac{1}{2}O_2$$

$$GA \xrightarrow{R^{decom}_{GA}} X$$

GENERAL DYNAMICAL MODEL DERIVATION

Bastin, G. and D. Dochain (1990). *On-line estimation and adaptive control of bioreactors*, Amsterdam, Oxford, New York, Tokyo: Elsevier.

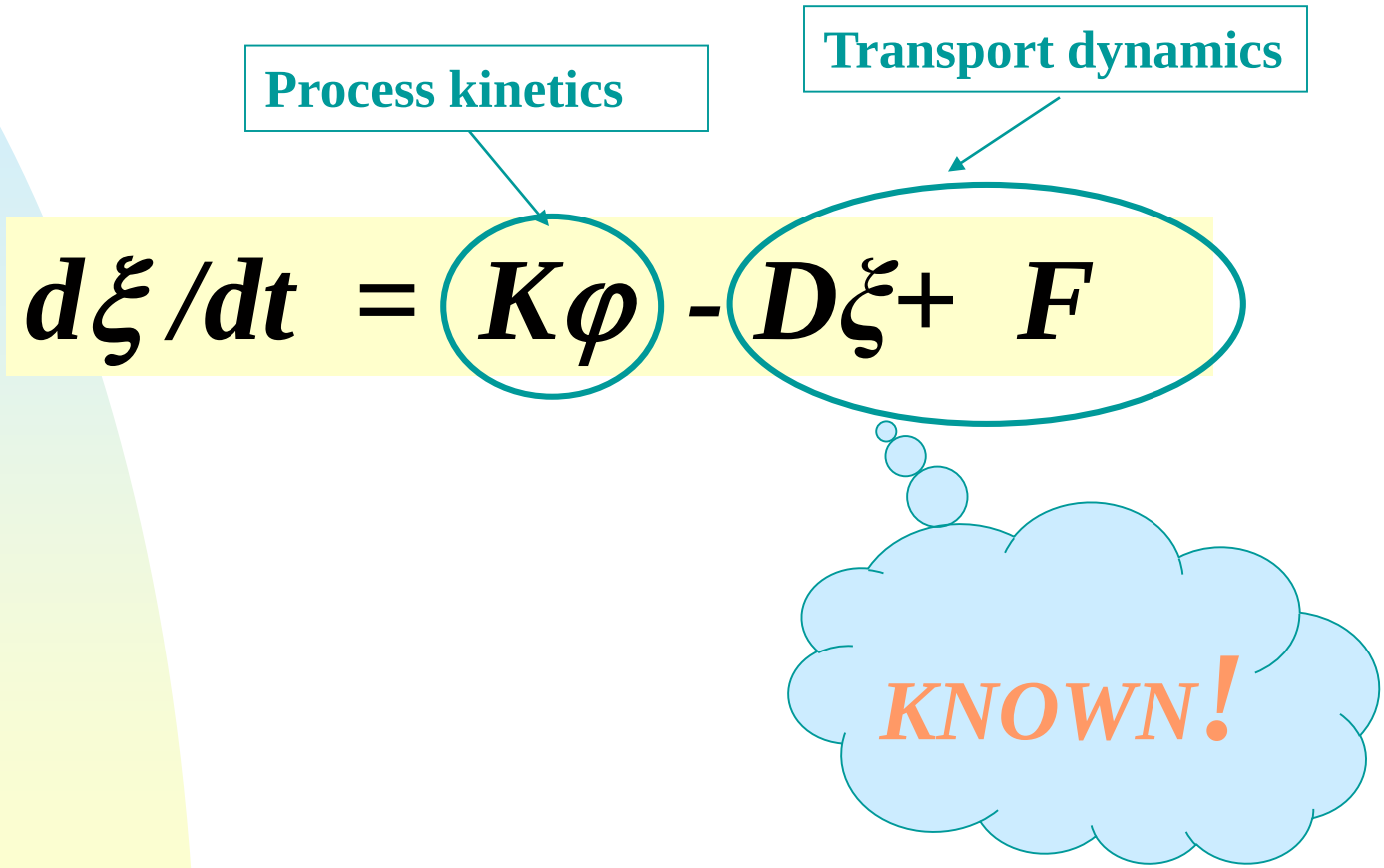
Dochain, D. and P. A. Vanrolleghem (2001). *Dynamical Modelling and Estimation in Wastewater Treatment Processes*, IWA Publishing

$$G \xrightarrow{\varphi_1} X$$

$$G + O_2 \xrightarrow{\varphi_2} GA$$

$$\frac{d\xi}{dt} = \sum_i (\pm) k_i \varphi_i - D\xi + F_i$$

GENERAL DYNAMICAL MODEL



GD MODEL TRANSFORMATION

$$\dot{\xi}_a = K_a\varphi - D\xi_a + F_a$$

measured

$$\dot{\xi}_b = K_b\varphi - D\xi_b + F_b$$

unmeasured

$$Z = A_0\xi_a + \xi_b$$

Auxiliary state variable

State partition

$$\dot{\xi} = K_a\varphi - D\xi_a + F_a$$

$$\dot{Z} = A_0F_a - D\xi_b + F_b$$

BIOMASS AND GLUCONIC ACID OBSERVERS

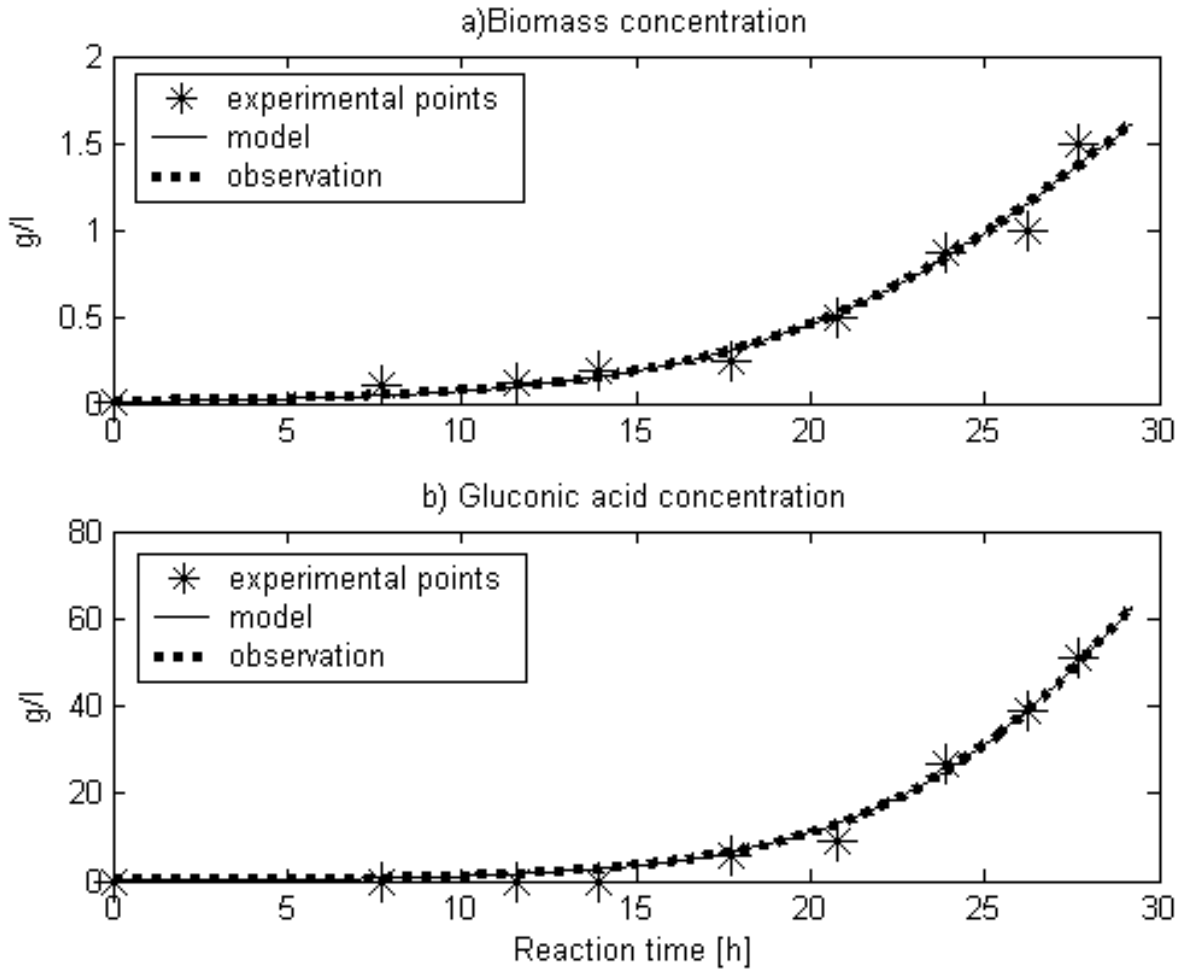
$$\dot{Z}_1 = -D Z_1 + D G_{in};$$

$$\dot{Z}_2 = -D Z_2 + K_L a (O_2^* - O_2);$$

$$X_e = \frac{1}{k_1} Z_1 - \frac{k_2}{k_1 k_3} (Z_2 - O_2) - \frac{1}{k_1} G$$

$$GA_e = \frac{1}{k_3} (Z_2 - O_2)$$

OBSERVERS CROSS VALIDATION



Adaptive linearizing control design for continuous process

Reaction scheme

$$G \xrightarrow{\varphi_1} X$$
$$G + O_2 \xrightarrow{\varphi_2} GA$$

General model

$$\dot{X} = \varphi_1 - DX$$
$$\dot{G} = -k_1\varphi_1 - k_2\varphi_2 - D(G - G_{in})$$
$$\dot{O}_2 = -k_3\varphi_2 - DO_2 + K_L a(O_2^* - O_2)$$
$$\dot{GA} = \varphi_1 - DGA$$

Reaction rates

$$\varphi_1 = GX\alpha_1$$
$$\varphi_2 = GO_2\alpha_2$$

General model in linear regression form

$$dX_e / dt = X_e G\theta_1 - DX_e$$
$$dG / dt = -X_e G\theta_2 - GO_2\theta_3 - D(G - G_{in})$$
$$dO_2 / dt = -GO_2\theta_4 - DO_2 - K_L a(O_2^* - O_2)$$
$$dGA_e / dt = GO_2\theta_5 - DGA_e$$

Input (***D***)/output(***GA***) model

Reference model for the regulation error

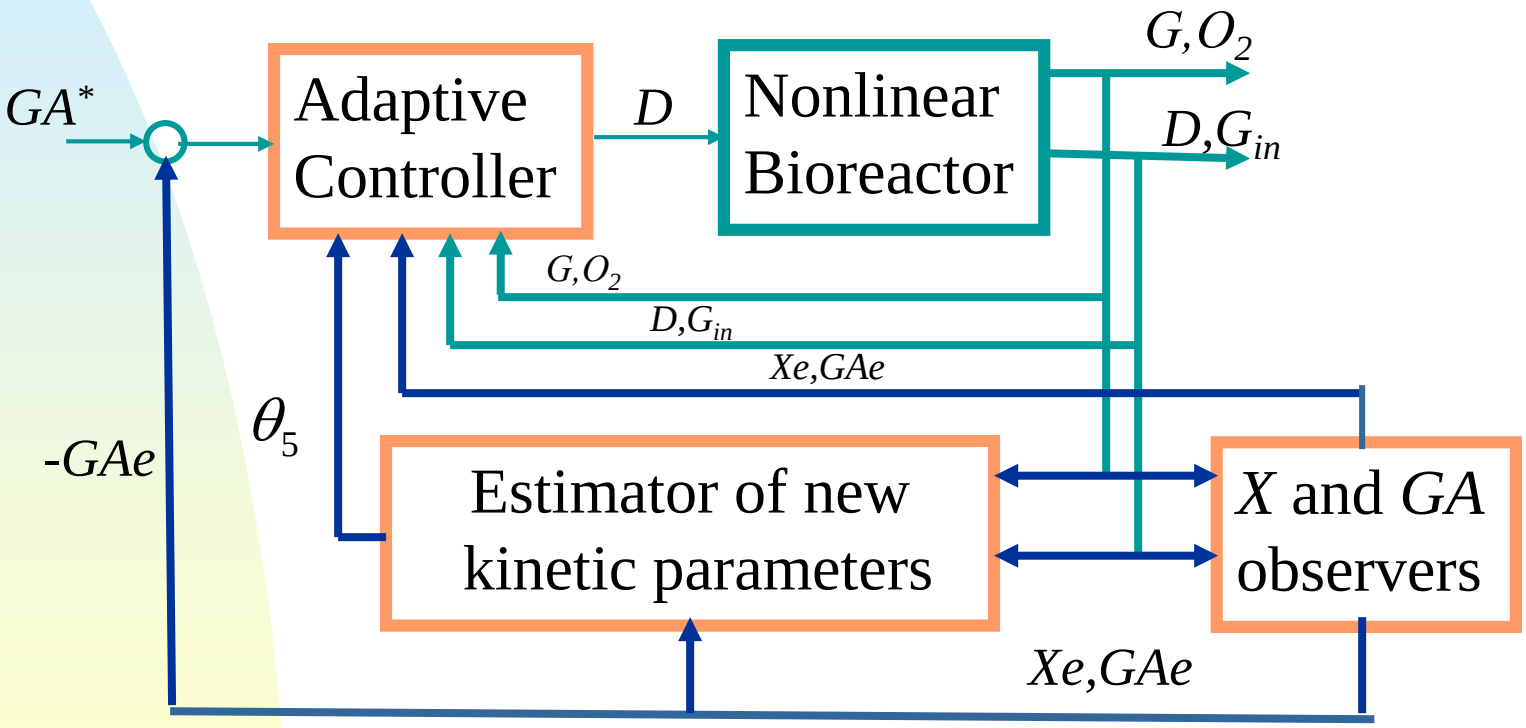
$$\frac{d(GA^* - GA_e)}{dt} + \lambda(GA^* - GA_e) = 0$$

$$\frac{dG^*}{dt} = 0$$

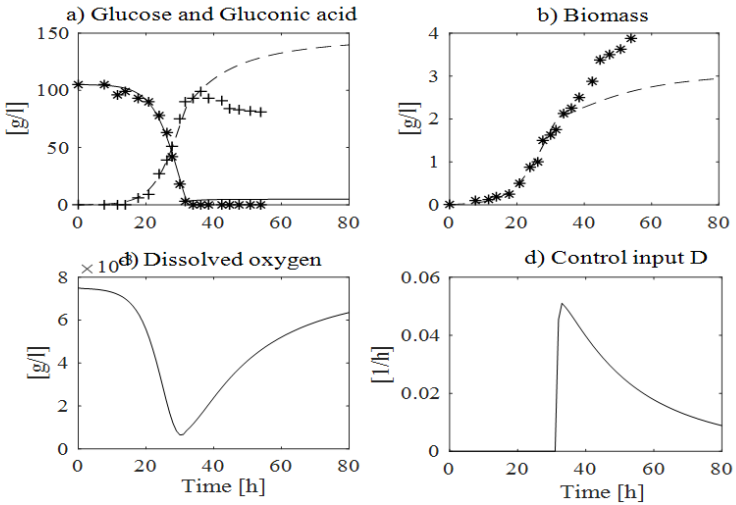
$$\lambda(GA^* - GA_e) = \frac{dGA_e}{dt}$$

$$D = \frac{-\lambda(GA^* - GA_e) + GO_2\theta_5}{GA_e}$$

CONTROL SCHEME

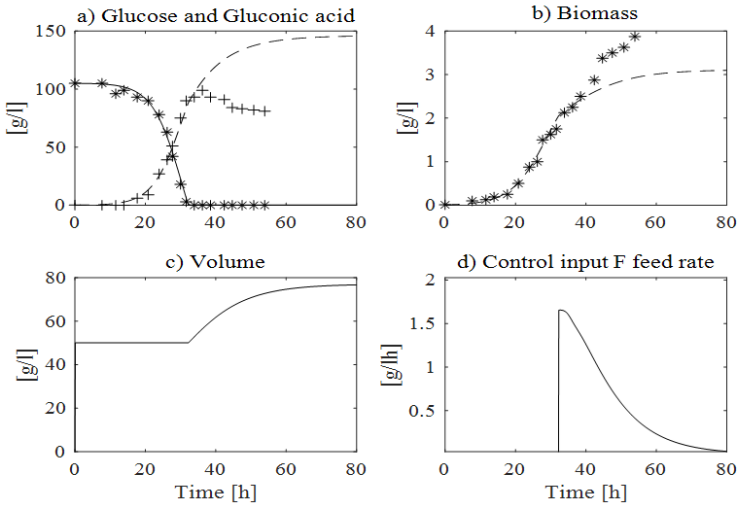


Continuous Control of Glucose concentration



$$D = \frac{-\lambda(G^* - G) - X_e\, G\theta_2 - GO_2\theta_3}{G - G_{in}}$$

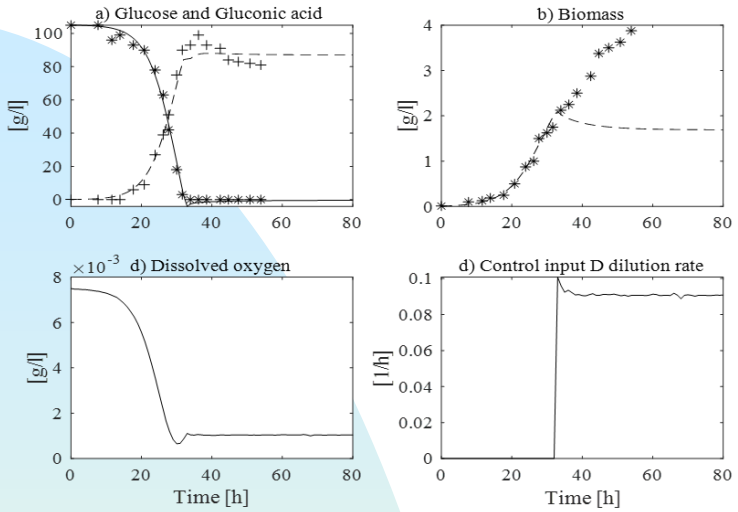
Fed-Batch Control of Glucose concentration



$$F = \frac{\boldsymbol{G_{in}}(-\lambda(G^* - G) - X_e\, G\theta_2 - GO_2\theta_3)}{G - G_{in}}$$

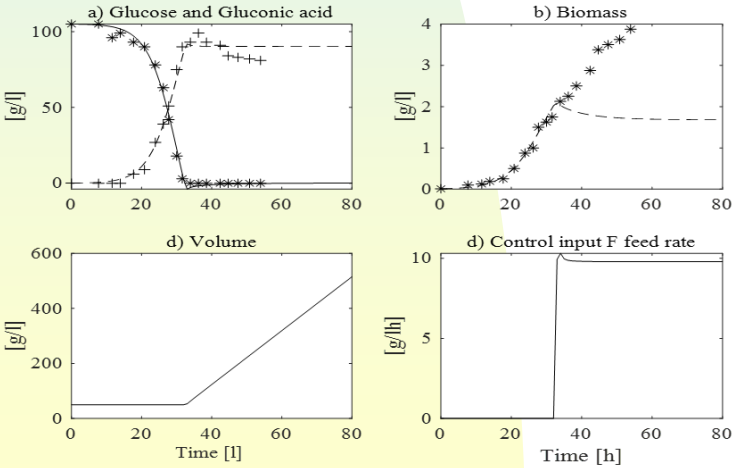
$dV/dt = F$

Continous Control of Gluconic Acid Concentration



$$D = \frac{-\lambda(GA^* - GA_e) + GO_2\theta_5}{GA_e}$$

Fed-Batch Control of Gluconic Acid Concentration



$$F = \frac{V(\lambda(GA^* - GA_e) - GO_2\theta_5)}{GA_e}$$

$$dV/dt = F$$

ACKNOWLEDGEMENTS

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Thanks for your attention