Modelling and simulation

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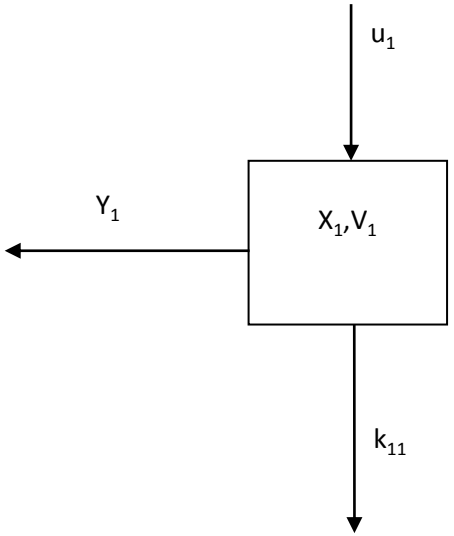
Sensitivity analysis of model

- Sensitivity analysis aims to find an optimal experiment, which could provide the best measurement of a physiological process.
- Sensitivity analysis ensures that the quality of the measured data is sufficient to identify the model parameters.
- Sensitivity analysis can be carried out by direct differentiation of model output (eg, drug concentration or amount), with respect to the parameter of interest.

1-compartmental model



Differential equations

$$\dot{X}_1 = -k_{11} \cdot X_1 + u_1$$
$$Y_1 = \frac{1}{V_1} \cdot X_1$$

State space notation

$$X = [X_1] \quad Y = [Y_1] \quad U = [u]$$
$$A = [-k_{11}]$$
$$\mathrm{B} = [1]$$
$$C = \left[\frac{1}{V_1}\right]$$

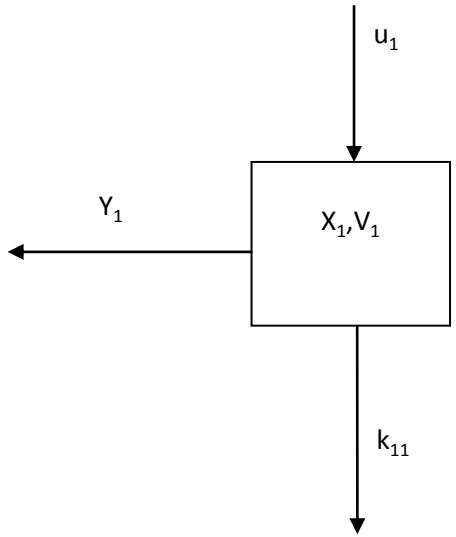
1-compartmental model

Sensitivity equations

$$\dot{\lambda} = A \cdot \lambda + H \cdot X$$
$$\eta = C \cdot \lambda + V \cdot X$$

Sensitivity matrix

$$H_1 = \frac{\partial A}{\partial k_{11}} = [-1] \qquad V_1 = \frac{\partial C}{\partial k_{11}} = [0]$$
$$H_2 = \frac{\partial A}{\partial V_1} = [0] \qquad V_2 = \frac{\partial C}{\partial V_1} = [-\frac{1}{{V_1}^2}]$$



K₁₁:

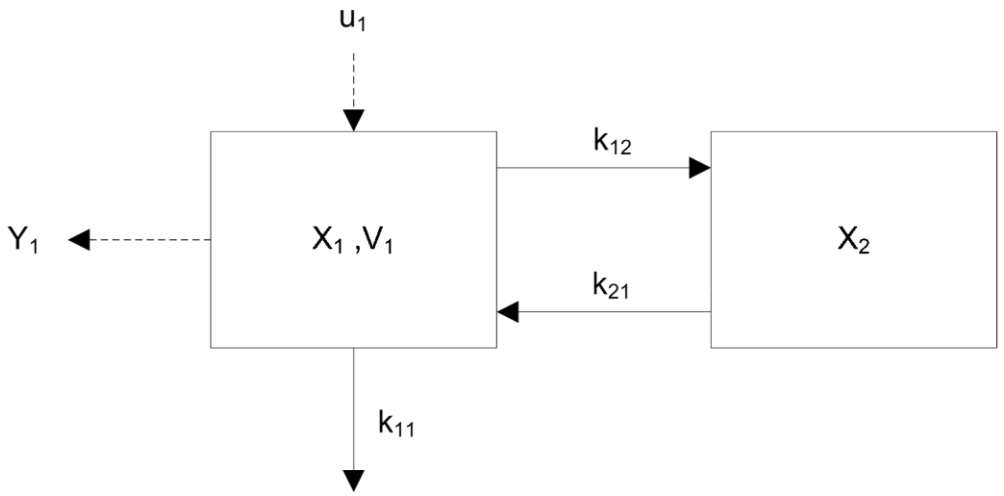
$$\dot{\lambda} = -k_{11} \cdot \lambda - x_1$$
$$\eta = \frac{\lambda}{V_1}$$

V₁:

$$\dot{\lambda} = -k_{11} \cdot \lambda$$
$$\eta = \frac{\lambda}{V_1} - \frac{x_1}{{V_1}^2}$$

Practice 2 - assignment

- 2-compartmental model



Practice 2 - assignment

- Compose sensitivity analysis
  - Define differential equations of the model
  - Define matrix A, B, C, D
  - Define sensitivity equations
  - Define sensitivity matrix
- Compose model in Simulink
  - Model parameters (k12=0.7 mg/h, k11=0.8 mg/h, k21=0.9 mg/h,V1=5l, u(0)=200 mg)
  - Including sensitivity of model parameters

Practice 2 – desired output

- Model file *. mdl with correctly described blocks
- Short paper in *. pdf containing
  - Block diagram of the model
  - Definition equation model
  - Matrices A, B, C, D
  - Sensitivity equations
  - Sensitivity matrix
  - Graphical output of the simulation – sensitivity analysis for state X and output Y with respect model parameters, outputs of model (amount, concentration).