1 ConstantAndMultiplicativeGaussianErrorModel

An error model which assumes that the model error is a mixture between a Gaussian base-level noise and a Gaussian heteroscedastic noise.

A mixture between a Gaussian base-level noise and a Gaussian heteroscedastic noise assumes that the observable biomarker X is related to the :class:‘MechanisticModel‘ output by

$$X(t, \psi, \sigma_{\text{base}}, \sigma_{\text{rel}}) = x^{\text{m}} + \left(\sigma_{\text{base}} + \sigma_{\text{rel}} x^{\text{m}} \right) \, \epsilon,$$

where $x^{\text{m}} := x^{\text{m}}(t, \psi)$ is the mechanistic model output with parameters ψ, and ϵ is a i.i.d. standard Gaussian random variable

$$\epsilon \sim \mathcal{N}(0, 1).$$

As a result, this model assumes that the observed biomarker values x^{obs} are realisations of the random variable X.

At each time point t the distribution of the observable biomarkers can be expressed in terms of a Gaussian distribution

$$p(x | \psi, \sigma_{\text{base}}, \sigma_{\text{rel}}) = \frac{1}{\sqrt{2\pi} \sigma_{\text{tot}}} \exp{\left(-\frac{\left(x-x^{\text{m}}\right)^2}{2\sigma^2_{\text{tot}}} \right)},$$

where $\sigma_{\text{tot}} = \sigma_{\text{base}} + \sigma_{\text{rel}} x^{\text{m}}$.

Extends :class:‘ErrorModel‘.

2 GaussianErrorModel

An error model which assumes that the model error follows a Gaussian distribution.

A Gaussian error model assumes that the observable biomarker X is related to the :class:‘MechanisticModel‘ output by

$$X(t, \psi, \sigma) = x^{\text{m}} + \sigma \epsilon,$$

where $x^{\text{m}} := x^{\text{m}}(t, \psi)$ is the mechanistic model output with parameters ψ, and ϵ is a i.i.d. standard Gaussian random variable

$$\epsilon \sim \mathcal{N}(0, 1).$$

As a result, this model assumes that the observed biomarker values x^{obs} are realisations of the random variable X.

At each time point t the distribution of the observable biomarkers can be expressed in terms of a Gaussian distribution

$$p(x | \psi, \sigma) = \frac{1}{\sqrt{2\pi} \sigma} \exp{\left(-\frac{\left(x-x^{\text{m}}\right)^2}{2\sigma^2} \right)}.$$

Extends :class:‘ErrorModel‘.

3 LogNormalErrorModel

An error model which assumes that the model error follows a Log-normal distribution.

A log-normal error model assumes that the observable biomarker X is related to the :class:‘MechanisticModel‘ output by

$$X(t, \psi, \sigma_{\text{log}}) = y\, \mathrm{e}^{\mu + \sigma_{\text{log}} \varepsilon},$$

where $y := y(t, \psi)$ is the mechanistic model output with parameters ψ, and ε is a i.i.d. standard Gaussian random variable

$$\varepsilon \sim \mathcal{N}(0, 1).$$

Here, σ_{log} is the standard deviation of $\log X$ and $\mu := -\sigma^2_{\text{log}}/2$ is chosen such that

$$\mathbb{E}[X] = y.$$

As a result, this model assumes that the observed biomarker values x^{obs} are realisations of the random variable X.

At each time point t the distribution of the observable biomarkers can be expressed in terms of a log-normal distribution

$$p(x|\psi, \sigma_{\text{log}}) = \frac{1}{\sqrt{2\pi}\sigma_{\text{log}} x} \exp\left(-\frac{\left(\log x - \log y + \sigma^2_{\text{log}}/2\right)^2}{2\sigma^2_{\text{log}}} \right).$$

Extends :class:‘ErrorModel‘.

4 MultiplicativeGaussianErrorModel

An error model which assumes that the model error is a Gaussian heteroscedastic noise.

A Gaussian heteroscedastic noise model assumes that the observable biomarker X is related to the :class:‘MechanisticModel‘ output by

$$X(t, \psi, \sigma_{\text{rel}}) = x^{\text{m}} + \sigma_{\text{rel}} x^{\text{m}}\, \epsilon,$$

where $x^{\text{m}} := x^{\text{m}}(t, \psi)$ is the mechanistic model output with parameters ψ, and ϵ is a i.i.d. standard Gaussian random variable

$$\epsilon \sim \mathcal{N}(0, 1).$$

As a result, this model assumes that the observed biomarker values x^{obs} are realisations of the random variable X.

At each time point t the distribution of the observable biomarkers can be expressed in terms of a Gaussian distribution

$$p(x|\psi, \sigma_{\text{base}}, \sigma_{\text{rel}}) = \frac{1}{\sqrt{2\pi}\sigma_{\text{tot}}} \exp\left(-\frac{(x - x^{\text{m}})^2}{2\sigma_{\text{tot}}^2}\right),$$

where $\sigma_{\text{tot}} = \sigma_{\text{rel}} x^{\text{m}}$.
Extends :class:‘ErrorModel‘.