Normal distribution

The density function of the Normal distribution has the following expression:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-1}{2}\left[\frac{x-\mu}{\sigma}\right]^2\right]$$

for x in $(-\infty, \infty)$.



Figure 89 Normal distribution panel

• Mean value (μ), with μ in (- ∞ , ∞); the default value is $\mu = 0e+000$.

2 Standard deviation value (σ), with $\sigma > 0$; the default value is $\sigma = 1e+000$.

3 Truncation value; the default value is in [0.001, 0.999].

There is the possibility to see the density formula through Quick Help by pressing the Normal button and close it by pushing again this button. The Quick Help functionality is the same for all distribution panels.

European Commission - IPSC	SimLab 2.2 – Reference Manual	110
----------------------------	-------------------------------	-----

LogNormal distribution

The density function of the LogNormal distribution has the following expression:

$$f(x) = \frac{1}{x \cdot \sigma \cdot \sqrt{2\pi}} \exp\left[\frac{-1}{2} \left[\frac{\ln(x) - \mu}{\sigma}\right]^2\right] \cdot \mathbf{1}_{(0,\infty)}(x)$$

for x in $(0, \infty)$.

Insert the information Name Normal Note Change the distribution and the parameters LogNormal Oe+000
Name Normale Note Change the distribution and the parameters LogNormal 0e+000 1e+000 0.658 0.658 0.658 0.658 0.658 0.001 - 0.999 LogNormal 0.564 0.376
Note Change the distribution and the parameters LogNormal 0e+000 1 0e+000 1 0e+000 1 0e+000 1 0.658 0.658 0.658 0.658 0.376
Change the distribution and the parameters LogNormal Image: Comparison of the parameters 0e+000 Image: Comparameters
LogNormal 0e+000 1e+000 0.658 0.658 0.658 0.658 0.658 0.658 0.001 - 0.999 LogNormal 0.658 0.376 0.376
0e+000 1e+000 0.658 0.658 0.658 0.658 0.658 0.001 - 0.999 LogNormal
1e+000 2 0.658 - LogNormal 0.564 - 0.470 - 0.376 - 0.376 - 0.470 - 0.470 -
0.658 0.564 0.470 0.376
0.658
0.564 - 0.470 - 0.376 -
0.376 - {
- (
0.282 - (
0.188
0.094
0.000 0.48 0.95 1.43 1.90 2.38 2.86 3.33 3.81
Apply Reset <u>O</u> K Cancel

Figure 90 Log-Normal distribution panel

Distribution parameters

 $\mathbf{1}$ μ parameter; the default value for μ is 0.

2 σ parameter; the default value for σ is 1.

3 Truncation value; the default value is in [0.001, 0.999].

Mean value: $\exp\left(\mu + \frac{1}{2}\sigma^2\right)$ Standard deviation: $\exp\left(2\mu + 2\sigma^2\right) - \exp\left(2\mu - \sigma^2\right)$

European Commission - IPSC	SimLab 2.2 – Reference Manual	111
----------------------------	-------------------------------	-----

Uniform distribution

The density function of the Uniform distribution has the following expression:

$$f(x) = \sum_{i=1}^{n} \frac{Weight_{i}}{RightVal_{i} - LeftVal_{i}}$$

with *n* number of intervals.

H UniformDistribution	_	. 🗆 🗙
Insert the information		
Name Normale		
Noto		
Change the distributio	on and the parameters	
Uniform		
	Left Val Bight Val Weight	
2 SAVE)
	·	
1.000		
0.957	<u>. Un</u>	rorm
0.714 -		
0.571 —		
0.429 —		
0.286 —		
0.143 —		
0.000		
0.00 0.13	0.25 0.38 0.50 0.63 0.75 0.88 1.00	
<u>A</u> pply I	Reset <u>Q</u> K Cancel	

Figure 91 Uniform distribution panel

Buttons description 1 LOAD button. The user can select this button to load a set of intervals for the current uniform distribution. This list of intervals will overwrite any previous list of intervals present in the matrix.



3 ADD button. This button is used to insert a new interval for the current uniform distribution. For each interval, the user has to insert the left bound, the right bound and the relative weight of the interval. The intervals can't overlap and the sum of the weights must be equal to 1.

DEL button. With this button the user may delete any interval present in the matrix. The user must select one interval before pressing the DEL button. After deleting an interval, the weight of the remaining elements must be corrected.

European Commission - IPSC	SimLab 2.2 – Reference Manual	112
----------------------------	-------------------------------	-----

APPENDIX A

ParametersThis area contains the parameters that characterise the uniform distribution:areaRightVal $_i$ and LeftVal $_i$ are the extreme values of i-th subinterval so that

(RightVal_{*i*} - LeftVal_{*i*}) > 0 for each *i*;

Weight i is the weight of the i-th subinterval, the sum of all the weights must be equal to 1.

The user can modify each value double clicking the matrix item.

Mean Value:
$$\sum_{i=1}^{n} \left(\frac{LeftVal_{i} + RightVal_{i}}{2} \right) * w_{i}$$

Standard deviation:
$$\sqrt{\sum_{i=1}^{n} \left(\frac{(LeftVal_{i}^{3} - RightVal_{i}^{3})}{LeftVal_{i} - RightVal_{i}} * \frac{1}{3} * w_{i} \right)}$$

European Commission - IPSC	SimLab 2.2 – Reference Manual	113
----------------------------	-------------------------------	-----

LogUniform distribution

The density function of the LogUniform distribution has the following expression:

$$f(x) = \sum_{i=1}^{n} \frac{Weight_{i}}{x \cdot (\ln(RightVal_{i}) - \ln(LeftVal_{i}))}$$

with *n* number of intervals.

R LogUniformDistribution	_ 🗆 ×
Insert the information	
Name Normale	
Note	
Change the distribution and the parameters	
Left Val Right Val Weight	
LOAD 1.000000 2.718282 1.000000 A DEL	
1.000 0.857 0.714 0.571 0.429 0.286 0.143 0.000 1.00 1.21 1.43 1.64 1.86 2.07 2.29 2.50 2.72	LogUniform
Apply Reset <u>D</u> K	Cancel

Figure 92 LogUniform distribution panel

Mean Value (
$$\mu$$
): $\sum_{i=1}^{n} \frac{RightVal_{i} - LeftVal_{i}}{\log(RightVal_{i}) - \log(LeftVal_{i})}$

Standard deviation:

$$\sqrt{\sum_{i=1}^{n} \left(\frac{RightVal_{i}^{2} - LeftVal_{i}^{2}}{2 \cdot \left(\log(RightVal_{i}) - \log(LeftVal_{i})\right)}\right)} + \mu^{2} - 2\mu \cdot \frac{RightVal_{i} - LeftVal_{i}}{\log(RightVal_{i}) - \log(LeftVal_{i})}$$

European Commission - IPSC	SimLab 2.2 – Reference Manual	114
----------------------------	-------------------------------	-----

Distribution

parameters

Weibull distribution

The density function of the Weibull distribution has the following expression:

$$f(x) = \frac{\beta}{n} * \left[\frac{x-b}{n}\right]^{\beta-1} \cdot \exp\left[-\left(\frac{x-\beta}{n}\right)^{\beta}\right]$$



Figure 93 Weibull distribution panel

- **1** β value with $\beta > 0$; the default value for β is 1.
- **2** n value with n > 0; the default value for n is 1.
- **3** b value with $b \ge 0$; the default value for b is 0.
- Right truncation value; the default value is 0.999

Mean value:
$$n \cdot \Gamma\left(1 + \frac{1}{\beta}\right) + b$$

Standard deviation: $\sqrt{n^2 \cdot \left[\Gamma\left(1 + \frac{2}{\beta}\right) - \Gamma^2\left(1 + \frac{1}{\beta}\right)\right]}$

European Commission - IPSC

Constant factor

The user may insert constant factors using this panel. Constant factors are excluded by the sample generation process.

88 Constant		_ 🗆 ×
Insert the information		
Name nonameConst		
Note		
Change the distribution and the parameters		
Constant		
Te+000 Value		
Reset	ОК	Cancel

Figure 94 Constant distribution panel

• This field specifies the value of the constant factor; the default value for a constant is 1.

European Commission - IPSC	SimLab 2.2 – Reference Manual	116
----------------------------	-------------------------------	-----

Exponential distribution

The density function of the Exponential distribution has the following expression:

```
f(x) = \lambda \cdot \exp\left[-\lambda \cdot (x-b)\right]
```

Exponential Distribution
Insert the information
Name Normale
Note
Change the distribution and the parameters
Exponential
1e+000 λ Right Truncation: 0.999
2 0е+000 ь
1.000 <u>Exponential</u> 0.857 <u>0</u> .714 <u>0</u> .571 <u>0</u> .429 <u>0</u> .286 <u>0</u> .143 <u>0</u> 0
0.000
Apply Reset <u>OK</u> Cancel

Figure 95 Exponential distribution panel

Distribution parameters

λ value with λ > 0; the default value for λ is 1.
b value with b > 0 and x ≥ b; the default value for b is 0.
Right truncation value; the default value is 0.999.

Mean value:
$$\frac{1}{\lambda} - b$$

Standard deviation: $\frac{1}{\lambda^2}$

Distribution parameters

Gamma distribution

The density function of the Gamma distribution has the following expression:

$$f(x) = \frac{\lambda^{\mathrm{r}}}{\Gamma(\mathrm{r})} * (x - \mathrm{b})^{\mathrm{r}-1} * \exp(-\lambda * (x - \mathrm{b}))$$

🗱 Gamma Distribution	
Insert the information	
Name Normale	
Note	
Change the distribution and the parameters	
Gamma	
1et 1	Right Truncation 0.999
le+ λ	-
0e+000 b	
1.000 0.857 0.714 0.571 0.429 0.286 0.143 0.000 0.000 0.000 0.63 1.25 1.88 2.50 3.13 Аррly Reset	<u>G</u> amma 3.75 4.38 5.00 <u>OK</u> Cancel

Figure 96 Gamma distribution panel

- **1** r value with r > 0; the default value for r is 1.
- **2** λ value with $\lambda > 0$; the default value for λ is 1.
- **3** b value with $b \ge 0 \& x \ge b$; the default value for b is 0.
- **4** Right truncation value; the default value is 0.999.

Mean value: $\frac{r}{\lambda} + b$

Standard deviation: $\sqrt{\frac{r}{\lambda^2}}$

Beta distribution

The density function of the Beta distribution density function has the following expression:

$$f(x) = \frac{1}{B(\alpha, \beta)} * \frac{1}{b-a} * \left[\frac{x-a}{b-a}\right]^{\alpha-1} * \left[\frac{b-x}{b-a}\right]^{\beta-1}$$

🕷 BetaDistribution 📃 🗆 🗙
Insert the information
Name Normale
Note
Change the distribution and the parameters
Beta 💌
1 2e+000 α Β 0e+000 a
2e+000 β
1500
1.071 -
0.857 —
0.643 —
0.429 -
0.214 -
0.00 0.13 0.25 0.38 0.50 0.63 0.75 0.88 1.00
Apply Reset <u>D</u> K Cancel

Figure 97 Beta distribution panel

Distribution parameters

α value with α > 0; the default value for α is 2.
 β value with β > 0; the default value for β is 2.
 a value with a < b; the default value for a is 0.
 b value; the default value for b is 1.

Mean value:
$$\frac{\alpha}{\alpha + \beta} * (b - a)$$

Standard deviation: $\sqrt{\frac{\alpha * \beta}{(\alpha + \beta + 1) * (\alpha + \beta)^2} * (b - a)^2}$

European Commission - IPSC	SimLab 2.2 – Reference Manual	119
----------------------------	-------------------------------	-----

Triangular distribution

The density function of the Triangular distribution has the following expression:

$$f(x) = \begin{cases} \frac{2*(x-\alpha)}{(\beta-\alpha)*(\gamma-\alpha)} & \alpha \le x \le \beta \\ \frac{2*(\gamma-x)}{(\gamma-\beta)*(\gamma-\alpha)} & \beta \le x \le \gamma \end{cases}$$

🗱 Triangular Distribution	_ 🗆 ×
Insert the information	
Name Normale	
Note	
Change the distribution and the parameters	
1e+000	
2e+000	
· · · · · · · · · · · · · · · · · · ·	
1.000 -	<u>T</u> riangular
0.857	
0.714	
0.571	
0.286 -	
0.143 -	
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.0	0
Apply Reset <u>O</u> K C	Cancel

Figure 98 Triangular distribution panel

Distribution parameters

 $\mathbf{0}$ α value; the default value for α is 0.

2 β value; the default value for β is 1.

3 γ value with $\alpha \le \gamma < \beta$ or $\alpha < \gamma$. $\le \beta$; the default value for γ is 0.5.

Height of β point (h): $\frac{2}{(\gamma - \alpha)}$

Mean

$$\frac{h}{3(\beta-\alpha)} \cdot \left[\beta^{3} - \alpha^{3}\right] - \frac{\alpha \cdot h}{2(\beta-\alpha)} \left[\beta^{2} - \alpha^{2}\right] + \frac{-h}{3(\gamma-\beta)} \left[\gamma^{3} - \beta^{3}\right] + \frac{1}{2} \left(\frac{\beta \cdot h}{(\gamma-\beta)} + h\right) \cdot \left[\gamma^{2} - \beta^{2}\right]$$

Standard deviation:

$$\left(\frac{h}{4(\beta-\alpha)}\left[\beta^{4}-\alpha^{4}\right]-\frac{\alpha\cdot h}{3(\beta-\alpha)}\left[\beta^{3}-\alpha^{3}\right]+\right.\\\left.+\frac{-h}{4(\gamma-\beta)}\left[\gamma^{4}-\beta^{4}\right]+\frac{1}{3}\left(\frac{\beta\cdot h}{\gamma-\beta}+h\right)\cdot\left[\gamma^{3}-\beta^{3}\right]-\mu^{2}\right)^{\frac{1}{2}}$$

European Commission - IPSC

SimLab 2.2 – Reference Manual

120

Relation

This panel represents a special case among the input factors selection panels; the user can create a relation between inputs factors using the expression editor.

Panel	8 Relation	
description	Insert the information	
L	Name Factor3	
	Note	
	Change the distribution and the pa	arameters
	Relation	
	Factors' list	Available operations
	Factor1 Factor2	acos() 7 8 9 / Pow () 4 5 6 * 1 2 3 - 0 . +
	Factor1*1.5	
	Apply Reset	OK Cancel

Figure 99 Relation panel

Factors list. This field shows the available inputs factors; by double clicking an input factor, it is possible to insert that factor in the expression visualized in 3.

Available operations. In this section of the panel the user can select some functions and basic operations to apply to the inputs factors. This section has the same functionality of a calculator with field 3 as display.

Expression field. This field displays the current expression; it is possible to insert the expression through "Available operations" or directly through the keyboard.

European Commission - IPSC SimLab 2.2 – Reference Manual 121	European Commission - IPSC	SimLab 2.2 – Reference Manual	121
--	----------------------------	-------------------------------	-----

Discrete distribution

The density function of the discrete distribution has the following expression:

$$f(x) = Weight_i I_{(x_1..x_n)}$$

where $I_{(x_1,x_2)}$ is 1 in the x's points 0 otherwise.

Discrete Distribution				
Insert the information				
Name noname1				
Note				
Change the distribution	on and the para	meters		
Discrete	-			
	-		T	
•	Val	Weight]	B
LOAD	0.000000	0.260000		
SAVE	0.500000	0.300000		9
	1.000000	0.240000	-	
0.360 —				Discrete
0.309 —				
0.257 —				
0.206 —		•		
0.154				
0.103 —				
0.051 —				
0.000				1
-0.10 0.05	0.20 0.35 0.	50 0.66 0.8	.1 0.96 1.	.11
<u>Apply</u> F	Reset		<u>></u> K	Cancel

Buttons description

Figure 100 Uniform distribution panel

ULOAD button. The user can select this button to load a set of points for the current discrete distribution. This list of points will overwrite any previous list of points present in the matrix.

2 SAVE button. This button allows the user to save in a file the current points for the discrete distribution.

3 ADD button. This button is used to insert a new point for the current discrete distribution. For each interval, the user has to insert the value of the point and the relative weight of the point. Points can't overlap and the sum of the weights must be equal to 1.

4 DEL button. With this button the user may delete any point present in the matrix. The user must select one interval before pressing the DEL button. After deleting an interval, the weight of the remaining elements must be corrected.

European Commission - IPSC	SimLab 2.2 – Reference Manual	122
----------------------------	-------------------------------	-----

ParametersThis area contains the parameters that characterise the discrete distribution.areaWeight $_i$ is the weight of point i the sum of weights must be equal to 1.

By double clicking an item in the 'Parameters area' the user can modify its value .

Mean Value: $\sum_{i=1}^{n} w_i * x_i$ for each x in which the distribution is defined

Standard deviation: $\sqrt{\sum_{i} (x_i - \mu_x)^2 * w_i}$

European Commission - IPSC	SimLab 2.2 – Reference Manual	123
----------------------------	-------------------------------	-----