

# LogLogistic likelihood

## Parametrisation

The LogLogistic distribution has cumulative distribution function

$$F_0(y) = \frac{1}{1 + \lambda y^{-\alpha}}, \quad y > 0$$

if `variant=0`, or

$$F_1(y) = \frac{1}{1 + (\lambda y)^{-\alpha}}, \quad y > 0$$

if `variant=1`, where

$\alpha > 0$  is a shape parameter, and

$\lambda > 0$  is a scale parameter.

## Link-functions

The parameter  $\lambda$  is linked to the linear predictor, by default as

$$\lambda = \exp(\eta)$$

## Hyperparameters

The  $\alpha$  parameter is represented as

$$\theta = \log \alpha$$

and the prior is defined on  $\theta$ .

## Specification

- family equals `loglogistic` (regression) or `loglogisticsurv` (survival)
- `variant=0` (default) or 1, choosing between parameterisation  $F_0$  or  $F_1$ .
- Required arguments:  $y$  (regression) or an `inla.surv`-object using `inla.surv()` (for survival data)

## Hyperparameter specification and default values

### Regression:

**doc** The loglogistic likelihood

### hyper

#### theta

**hyperid** 80001  
**name** log alpha  
**short.name** alpha  
**initial** 1  
**fixed** FALSE  
**prior** loggamma  
**param** 25 25

```
to.theta function(x) log(x)
from.theta function(x) exp(x)
```

**survival** FALSE

**discrete** FALSE

**link** default log neglog

**pdf** loglogistic

### Survival:

**doc** The loglogistic likelihood (survival)

**hyper**

**theta**

```
hyperid 80011
name log alpha
short.name alpha
initial 1
fixed FALSE
prior loggamma
param 25 25
to.theta function(x) log(x)
from.theta function(x) exp(x)
```

**survival** TRUE

**discrete** FALSE

**link** default log neglog

**pdf** loglogistic

### Example

In the following example we estimate the parameters in a simulated case

```
rloglogistic = function(n, lambda, alpha, variant=0)
{
  u = runif(n)
  if (variant == 0) {
    y = (lambda/(1.0/u - 1.0))^(1.0/alpha)
  } else if (variant == 1) {
    y = (1.0/(1.0/u - 1.0))^(1.0/alpha) / lambda
  } else {
    stop("ERROR")
  }
}
```

n = 1000

alpha = 2.1

```

x = c(scale(runif(n)))
eta = 1.1+2.2*x
lambda = exp(eta)

for(variant in 0:1) {

  print(paste("variant=", variant))
  y = rloglogistic(n, lambda = lambda,
                  alpha = alpha,
                  variant = variant)

  formula = y ~ 1 + x
  r=inla(formula,
        family ="loglogistic",
        data=data.frame(y, x),
        control.family = list(variant = variant))
  print("REGRESSION")
  print(summary(r))

  event = rep(1,n)
  formula=inla.surv(y,event) ~ 1 + x
  r=inla(formula,
        family ="loglogisticsurv",
        data = list(y=y, event=event, x=x),
        control.family = list(variant = variant))
  print("SURVIVAL")
  print(summary(r))
}

```

## Notes

- Loglogisticsurv model can be used for right censored, left censored, interval censored data. If the observed times  $y$  are large/huge, then this can cause numerical overflow in the likelihood routine. If you encounter this problem, try to scale the observatios, `time = time / max(time)` or similar.