

# The RW2d-model

## Parametrization

The 2-dimensional random walk model is defined on a regular grid. The full conditional distributions for the nodes in the interior of the grid are given by:

$$E(x_i | \mathbf{x}_{-i}, \tau) = \frac{1}{20} \left( 8 \begin{array}{ccccc} \circ & \circ & \circ & \circ & \circ \\ \circ & \circ & \bullet & \circ & \circ \\ \circ & \bullet & \bullet & \bullet & \circ \\ \circ & \circ & \bullet & \circ & \circ \\ \circ & \circ & \circ & \circ & \circ \end{array} - 2 \begin{array}{ccccc} \circ & \circ & \circ & \circ & \circ \\ \circ & \bullet & \bullet & \bullet & \circ \\ \circ & \bullet & \bullet & \bullet & \circ \\ \circ & \bullet & \bullet & \bullet & \circ \\ \circ & \circ & \circ & \circ & \circ \end{array} - 1 \begin{array}{ccccc} \circ & \circ & \bullet & \circ & \circ \\ \circ & \circ & \bullet & \circ & \circ \\ \circ & \bullet & \bullet & \bullet & \bullet \\ \circ & \circ & \bullet & \circ & \circ \\ \circ & \circ & \bullet & \circ & \circ \end{array} \right), \quad (1)$$

$$\text{Prec}(x_i | \mathbf{x}_{-i}, \tau) = 20\tau. \quad (2)$$

Necessary corrections to equations (1) and (2) near the boundary can be found using the stencils in [Terzopoulos, 1988]. For a detailed description of this model see [Rue and Held, 2005, Sec. 3.4.2].

## Hyperparameters

The precision parameter  $\tau$  is the only hyperparameter,  $\theta = \tau$ . It is represented internally as  $\log \tau$  and the prior is assigned to  $\log \tau$ .

## Specification

The `rw2d` model is specified inside the `f()` function as:

```
f(<whatever>, model="rw2d", nrow=<n.of rows>, ncol=<n.of columns>,  
  prior=<prior.model.theta>,  
  param=c(<param.prior.theta>))
```

## Example

```
nrow=50  
ncol=25  
n = nrow*ncol  
s.mat=matrix(NA,nrow=nrow,ncol=ncol)  
j=1:ncol  
for(i in 1:nrow)  
  s.mat[i,j] = 0.1*(i+2*j)  
  
## a covariate  
z.mat=matrix(runif(nrow*ncol),nrow,ncol)  
  
## noise  
noise.mat=matrix(rnorm(nrow*ncol, sd=0.3),nrow,ncol)  
  
## make simulated data  
y.mat = s.mat + 0.5*z.mat + noise.mat  
  
## convert matrices to the internal representation in INLA  
y = inla.matrix2vector(y.mat)  
z = inla.matrix2vector(z.mat)  
node = 1:n  
formula= y ~ z + f(node, model="rw2d", nrow=nrow, ncol=ncol)  
data=data.frame(y=y,z=z,node=node)  
## fit the model
```

```

result=inla(formula, family="gaussian", data=data)

#plot the posterior mean for 'node' with the truth
par(mfrow=c(2,1))
image(s.mat)
image(inla.vector2matrix(result$summary.random$node$mean,nrow,ncol))

```

## Notes

All indexes in the R-INLA library are one-dimensional so an appropriate mapping is required to get it into the ordering defined internally in `inla`; see `?inla.matrix2vector`, `?inla.vector2matrix`, `?inla.node2lattice` and `?inla.lattice2node`.

## References

- [Rue and Held, 2005] Rue, H. and Held, L. (2005). *Gaussian Markov Random Fields: Theory and Applications*, volume 104 of *Monographs on Statistics and Applied Probability*. Chapman & Hall, London.
- [Terzopoulos, 1988] Terzopoulos, D. (1988). The computation of visible-surface representations. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 10(4):417–438.