

# Package ‘SurfaceTortoise’

January 20, 2025

**Type** Package

**Title** Find Optimal Sampling Locations Based on Spatial Covariate(s)

**Version** 2.0.1

**Maintainer** Kristin Persson <kristin.persson@slu.se>

**Description** Create sampling designs using the surface reconstruction algorithm.  
Original method by: Olsson, D. 2002. A method to optimize soil sampling from ancillary data. Poster presenterad at: NJF seminar no. 336, Implementation of Precision Farming in Practical Agriculture, 10-12 June 2002, Skara, Sweden.

**Depends** R (>= 3.4.4)

**Imports** terra, gstat, sf

**Suggests** roxygen2, testthat (>= 3.0.0)

**License** MIT + file LICENSE

**URL** <https://CRAN.R-project.org/package=SurfaceTortoise>

**BugReports** <https://github.com/kriper0217/SurfaceTortoise/issues>

**Encoding** UTF-8

**RoxygenNote** 7.2.3

**Config/testthat/edition** 3

**NeedsCompilation** no

**Author** Kristin Persson [aut, cre, cph],  
Mats Soderstrom [ctb, cph],  
John Mutua [ctb]

**Repository** CRAN

**Date/Publication** 2023-05-09 07:00:10 UTC

## Contents

tortoise	2
<b>Index</b>	<b>5</b>

---

 tortoise

*tortoise*


---

### Description

Optimizing spatial sampling using the Surface Tortoise algorithm. Grid sampling and random sampling are also available. All three sampling designs can optionally be stratified by a square grid to ensure spatial coverage.

### Usage

```
tortoise(
  x = NULL,
  y = NULL,
  method = "directed",
  edge = 0,
  strat_size = NULL,
  min_dist = 0,
  p_idw = 2,
  nmax_idw = 8,
  resolution = NULL,
  filter = 1,
  stop_n = NULL,
  stop_dens = 1,
  plot_results = T
)
```

### Arguments

x	SpatRaster. Required for method = directed. The raster must have a defined coordinate system, which is projected, and must be of class numeric. If x has more than onelayer, the first principal component of the layers will be used for sampling.
y	SpatVector delineating the area to be sampled. Required for method = 'grid' and method = 'random'. Optional for method = 'directed'. The SpatVector must have a defined coordinate system, which is projected. If a SpatRaster is #' provided, the coordinate system shall be the same as for the raster. If x and y are not completely overlapping, their intersection will be sampled.
method	Sampling method: 'directed' = directed sampling (SurfaceTortoise algorithm), 'grid' = regular sampling (center points of strata) and 'random' = random points. Default is 'directed'.
edge	A positive number. Optional. Buffer zone (unit of the coordinate reference system) inside the sampled area border, where sampling is prohibited.
strat_size	A positive number, 0, or NULL. Optional. Cell side of a square stratification grid (unit of the coordinate reference system). If both strat_size and stop_n are specified, stop_n overruns this argument with an adjusted strat_size. If strat_size is NULL or 0, the sampling will be done without stratification.

<code>min_dist</code>	A positive number. Optional. Minimum distance allowed between samples. Valid for the 'random' and the 'directed' methods. one can for example set <code>min_dist</code> to the diameter of the sample support to prevent overlapping samples.
<code>p_idw</code>	An integer. Exponent used for idw-interpolation (method == 'directed'). Default = 2.
<code>nmax_idw</code>	An integer. Number of neighbouring samples used for idw-interpolation (method == 'directed'). Default = 8.
<code>resolution</code>	A positive number. Optional. If provided, the raster data will be resampled to this resolution.
<code>filter</code>	A positive integer. Side of the square window (number of raster cells, original resolution) used for mean filtering of the raster. Default = 1 (no filtering).
<code>stop_n</code>	A positive integer, or NULL. Optional. The number of samples to place. If NULL, it will be computed from the numbers of strata generated from the specified stratification size (argument <code>strat_size</code> ) and the number of samples to place per stratum (argument <code>stop_dens</code> ).
<code>stop_dens</code>	A positive integer. The number of samples to place in each stratum. Does not apply for method = 'grid' (always <code>stop_dens</code> = 1) and not for non-stratified sampling. Default = 1.
<code>plot_results</code>	Logical. Shall results be plotted? Default is FALSE.

## Details

The Surface Tortoise algorithm for directed sampling uses a raster to find optimal sample locations. The sampling strategy is based on the principle that an interpolation of the samples should be as similar as possible to the guide raster. First, the center point of the raster cell with the maximum deviation from the raster mean is sampled. Then, the raster cell with the maximum deviation from the first sampled raster cell is sampled. From then on, the values of the sampled raster cells are interpolated by inverse distance weighting (idw), and the center point of the raster cell with the largest absolute difference to the guide raster (the largest error) is sampled. A new idw interpolation is made and a new cell is sampled. This is repeated until a stopping criterion (`stop_n` or `stop_dens`) is reached. The sampling can be stratified by a square grid. When a sample has been placed in a stratum, no more samples will be placed in that stratum again until all other strata have been sampled. The likelihood for a clipped stratum, at the edge of the area to be sampled, is equal to the area of that stratum divided by the area of a full stratum. Samples are placed in raster cell center points.

The optional raster processing steps: is carried out in the following order: 1) mean filtering (argument: `filter`) 2) resampling to specified resolution (argument: `resolution`), 3) computation of first principal component (if `x` has multiple layers).

## Value

A list with 1) `sampled_raster` = the sampled raster (only if method == 'directed') 2) `samples` = a `SpatVector` of points (the sample locations) 3) `sampled_area` = a `SpatVector` of polygons (the sampled area). 4) `stratification` = a `SpatVector` of polygons (stratification grid). 5) `feedback` = a dataframe with generated text messages.

## References

Olsson, D. 2002. A method to optimize soil sampling from ancillary data. Poster presented at: NJF seminar no. 336, Implementation of Precision Farming in Practical Agriculture, 10-12 June 2002, Skara, Sweden.

## Examples

```
#load packages
require(terra)
require(gstat)
require(sf)
#create an example raster dataset
x<-rast(nrow=5, ncol=10, vals= sample(1:4, 50, replace=TRUE),crs=crs("EPSG:3857"))
x<-disagg(x, 10, 'bilinear')

#create an example SpatVector of polygons
a<-cbind(
  x=c(-100, -120, -75, 40, 100, 120, 50, -100),
  y=c(-50, 0, 50, 75, 40, -30, -60, -50)
)
y<-vect(a, "polygons"); crs(y)<-crs(x)

#do a directed stratified sampling for 25 samples. Let the stratification
#grid size be determined automatically and visualize the sampling
#procedure (default)
tortoise(x, y, stop_n=25)
```

# Index

tortoise, [2](#)