Package: SurfRough (via r-universe)

September 6, 2024

Title Calculate Surface/Image Texture Indexes

Version 0.0.1.0

Description Methods for the computation of surface/image texture indices using a geostatistical based approach (Trevisani et al. (2023) <doi:10.1016/j.geomorph.2023.108838>). It provides various functions for the computation of surface texture indices (e.g., omnidirectional roughness and roughness anisotropy), including the ones based on the robust MAD estimator. The kernels included in the software permit also to calculate the surface/image texture indices directly from the input surface (i.e., without de-trending) using increments of order 2. It also provides the new radial roughness index (RRI), representing the improvement of the popular topographic roughness index (TRI). The framework can be easily extended with ad-hoc surface/image texture indices.

Encoding UTF-8

Roxygen list(markdown = TRUE)

RoxygenNote 7.3.2

BugReports `https://github.com/strevisani/SurfRough/issues`

LazyData true

Depends R (>= 3.5.0), terra

Suggests tinytest

URL `https://github.com/strevisani/SurfRough`, `https://doi.org/10.5281/zenodo.7132160`

NeedsCompilation no

Maintainer Sebastiano Trevisani <`strevisani@iuav.it`>

Repository https://strevisani.r-universe.dev

RemoteUrl https://github.com/strevisani/surfrough

RemoteRef HEAD

RemoteSha b3f2c6ffa916695c87055edf8fbace961970c387

Contents

`anisoDir` *Calculate the direction of maximum continuity considering 4 directions*

Description

The input is represented by four rasters with the spatial variability index (e.g., MAD, variogram, etc.) computed in four directions (N-S, NE-SW, E-W, SE-NW)

Usage

```
anisoDir(N, NE, E, SE)
```

Arguments

`N`	Spatial variability along N-S direction
`NE`	Spatial variability along NE-SW direction
`E`	Spatial variability along E-W direction
`SE`	Spatial variability along SE-NW direction

Value

A raster with the direction (in degrees, geographical) of maximum continuity

---

`anisoDirL` *Calculate the direction of maximum continuity considering 4 directions*

Description

The input is represented by a list of rasters with the spatial variability index (e.g., MAD, variogram, etc.) computed in four directions (N-S, NE-SW, E-W, SE-NW)

Usage

```
anisoDirL(x)
```

Arguments

`x`	A list of rasters with the spatial variability along 4 directions (see function anisoDir())

Value

A raster with the direction (in degrees, geographical) of maximum continuity

---

`anisoR` *Calculate the index of anisotropy considering the spatial variability along 4 directions*

Description

The input is represented by four rasters with the spatial variability index (e.g., MAD, variogram, etc.) computed in four directions (N-S, NE-SW, E-W, SE-NW)

Usage

```
anisoR(N, NE, E, SE)
```

Arguments

`N`	Spatial vairability along N-S direction
`NE`	Spatial vairability along NE-SW direction
`E`	Spatial vairability along E-W direction
`SE`	Spatial vairability along SE-NW direction

Value

A raster with the index of anisotropy (min=0 max=1)

`anisoRL` *Calculate the index of anisotropy considering the spatial variability along 4 directions*

Description

The input is represented by a list of rasters with the spatial variability index (e.g., MAD, variogram, etc.) computed in four directions (N-S, NE-SW, E-W, SE-NW)

Usage

```
anisoRL(x)
```

Arguments

`x`	A list of rasters with the spatial variability along 4 directions (see function anisoR())

Value

A raster with the index of anisotropy (min=0 max=1)

`CalcMeans` *Calculate the mean of absolute values raised to an exponent found in a search window*

Description

With this you can compute variogram and madogram (but remember that for classical geostatistical indexes you need to divide the derived isotropic index by 2!)

Usage

```
CalcMeans(deltas, w, exponent)
```

Arguments

`deltas`	The values from which calculate the median of absolute values (i.e., directional differences of order K)
`w`	The moving window used (e.g. w=KernelCircular(3))
`exponent`	The exponent: increasing the exponent increase the sensitivity to outliers. Set 2 for Variogram and 1 for Madogram.

Value

A raster with the mean of absolute values in the search window

---

`CalcMedians` *Calculate the median of absolute values found in a search window for each raster in a list*

Description

Calculate the median of absolute values found in a search window for each raster in a list

Usage

```
CalcMedians(deltas, w)
```

Arguments

`deltas`	A list of rasters with the values from which calculate the median of absolute values (e.g., directional differences of order K)
`w`	The moving window used (e.g. w=KernelCircular(3))

Value

A list of rasters with the median of absolute values in the search window

---

`circularDispersionGV` *Compute circular variance of aspect (i.e. of the gradient vector)*

Description

Compute circular variance of aspect (i.e. of the gradient vector)

Usage

```
circularDispersionGV(inraster, window)
```

Arguments

`inraster`	The DEM from which compute the index
`window`	The moving window adopted for computing the index

Value

The raster with the computed index

Examples

```
# Gradient vector dispersion using a circular search window of radius 3.
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w=KernelCircular(3)
roughGrad=circularDispersionGV(dem,w)
plot(roughGrad)
```

`circularDispersionNV` *Compute circular variance of normal vectors to surface*

Description

Compute circular variance of normal vectors to surface, using the resultant vector length

Usage

```
circularDispersionNV(inraster, window)
```

Arguments

`inraster`	The DEM from which compute the index
`window`	The moving window adopted for computing the index

Value

The raster with the computed index

Examples

```
#
#Normal vector dispersion using a circular search window of radius 3.
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w=KernelCircular(3)
roughVDR=circularDispersionNV(dem,w)
plot(roughVDR)
```

`circularEigenNV` *Compute circular variance of normal vectors to surface*

Description

Compute circular variance of normal vectors to surface, using the eigen values (only for testing, very slow)

Usage

```
circularEigenNV(inraster, window)
```

Arguments

`inraster`	The DEM from which compute the index
`window`	The moving window adopted for computing the index

Value

The raster with the computed index

`k05ck2` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k05ck2
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k1c` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k1c
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k1ck2` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k1ck2
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k2c` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k2c
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k2ck2` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k2ck2
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k4c` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k4c
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k6c` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k6c
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`k8c` *basic kernels*

Description

Kernels for computing directional differences for specific directions and lag distances. These have been constructed using bilinear interpolation for directions out of main axes. The kernels are intended to be used with "Terra" focal functions (i.e., convolution).

Usage

```
k8c
```

Format

just matrices.

Source

Sebastiano Trevisani

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
#to see kernels (each one is a list with 4 kernels) of order 1
#These should be used with a detrended "surface"
#lag 1 pixel
k1c
#lag 2 pixels
k2c
#lag 4 pixels
k4c
#lag 6 pixels
k6c
#lag 8 pixels
k8c
#kernels of order 2 (differences of differences)
#these can be applied directly without detrending
#lag 05 pixel
k05ck2
#lag 1 pixel
k1ck2
#lag 2 pixels
k2ck2
```

`KernelCircular` *Build a circular moving window*

Description

Build a circular moving window

Usage

```
KernelCircular(radius)
```

Arguments

`radius`	The radius of the moving window

Value

A matrix with selected pixels

Examples

```
#A circular moving window with a radius of 3 pixels
w=KernelCircular(3)
w
```

`KernelRectangular` *Build a rectangular kernel of size X x Y*

Description

Build a rectangular kernel of size X x Y

Usage

```
KernelRectangular(lenx, leny)
```

Arguments

`lenx`	The size in pixels along x
`leny`	The size in pixels along y

Value

The matrix (square/rectangular) with the selected pixels

Examples

```
#A rectangular moving window 5x5 pixels
w=KernelRectangular(5,5)
w
```

`Madscan` *Calculate MAD basic indexes*

Description

Calculate MAD basic indexes considering a specif lag and difference of order K. It computes 3 indexes of roughness/image texture: isotropic/omnidirectional; direction of maximum continuity; anisotropy index. The anisotropy index is based on vector dispersion approach: 0 minimum anisotropy; 1 maximum anisotropy. The direction of anisotropy is in degrees according to geographical convention.

Usage

```
Madscan(inRaster, kernels, w)
```

Arguments

`inRaster`	The DEM/residual-dem from which to compute the indexes
`kernels`	The kernels to be used for computing the directional differences (e.g. order 1 or 2 for various lags)
`w`	The moving window adopted for computing the geostatistical index (i.e., MAD)

Value

A list of 3 rasters: 1)isotropic roughness; 2) direction of anisotropy;3)index of anisotropy.

References

1. Trevisani, S. & Rocca, M. 2015. MAD: Robust image texture analysis for applications in high resolution geomorphometry. Computers and Geosciences, vol. 81, pp. 78-92.
2. Trevisani, S. Teza, G., Guth, P., 2023. A simplified geostatistical approach for characterizing key aspects of short-range roughness. CATENA,Volume 223, ISSN 0341-8162,https://doi.org/10.1016/j.catena.2023.10

Examples

```
# MAD for lag 2 with differences of order 2 using a circular search window of radius 3.
# Using differences of order 1, you should
# apply these on a detrended surface/image.
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w=KernelCircular(3)
rough2c=Madscan(dem,k2ck2, w)
#Plot isotropic roughness
plot(rough2c$IsoRough)
#Plot anisotropy index/strenght
plot(rough2c$AnisoR)
```

`Meanscan` *Calculate less robust geostatistical indexes (mean of absolute differences raised to an exponent)*

Description

With this you can compute variogram and madogram (but remember that for classical geostatistical indexes you need to divide the derived isotropic index by 2!). Moreover you can calibrate the exponent in order to filter or enhance hotspots and discontinuities

Usage

```
Meanscan(inRaster, kernels, w, exponent)
```

Arguments

`inRaster`	The DEM/residual-dem from which to compute the indexes
`kernels`	The kernels to be used for computing the directional differences (e.g. order 1 or 2 for various lags)
`w`	The moving window adopted for computing the geostatistical index (i.e., MAD)
`exponent`	The exponent: increasing the exponent increase the sensitivity to outliers. Set 2 for Variogram and 1 for Madogram.

Value

A SpatRaster with 3 layers: 1)isotropic roughness; 2) direction of anisotropy; 3)index of anisotropy.

Examples

```
#' Variogram-like for lag 2 with differences of order 2 using a circular search window of radius 3.
# Using differences of order 1, you should
# apply these on a detrended surface/image.
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w=KernelCircular(3)
rough2c=Meanscan(dem,k2ck2, w,2)
#(divide by two if you need classical estimator)
plot(rough2c$IsoRough)
```

`RRI` *RRI: Radial Roughness index*

Description

Modified TRI, based on increments of order 2 (removing slope dependence) and correcting for diagonal distance. RRI modifies TRI (topographic ruggedness index) using increments of order 2, symmetrical to the central pixel, so as to remove the effect of local slope. This version corrects for the diagonal distance using bilinear interpolation. It uses a 5x5 kernel, consequently 12 directional differences of order k (2) are used in the estimation. One could also use a 3x3 kernel using only the 4 differences centered on the central pixel but the metric would be very noisy. The input is the DEM (no need to detrend).

Usage

```
RRI(x)
```

Arguments

`x`	The DEM from which to compute the index

Value

isotropic roughness (in the same units of input)

References

1. Riley, S. J., S. D. DeGloria, and R. Elliott. 1999. A terrain ruggedness index that quantifies topographic heterogeneity. Intermountain Journal of Science 5:23.
2. Wilson, M.F.J., O'Connell, B., Brown, C., Guinan, J.C. & Grehan, A.J. 2007. Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope". Marine Geodesy, vol. 30, no. 1-2, pp. 3-35.
3. Trevisani S., Teza G., Guth P.L., 2023. Hacking the topographic ruggedness index. Geomorphology https://doi.org/10.1016/j.geomorph.2023.108838

Examples

```
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w <- matrix(1, nrow=5, ncol=5)
roughTrick5x5=focal(dem, w=w, fun=RRI)
plot(roughTrick5x5)
```

`Trik2` *Improved TRI (with differences of order 2), removing slope dependence.*

Description

It is essentially a roughness radial index. TRIk2 modifies TRI (topographic ruggedness index) using increments of order 2, symmetrical to central pixel, so as to remove the effect of local slope. This version does not correct for diagonal distance. It uses a 5x5 kernel, consequently 12 directional differences of order k (2) are used in the estimation. One could also use a 3x3 kernel using only the 4 differences centered on the central pixel but the metric would be very noisy. The input is the DEM (no need to detrend).

Usage

```
Trik2(x)
```

Arguments

`x`	The DEM from which to compute the index

Value

isotropic roughness (in the same units of input)

References

1. Riley, S. J., S. D. DeGloria, and R. Elliott. 1999. A terrain ruggedness index that quantifies topographic heterogeneity. Intermountain Journal of Science 5:23.
2. Wilson, M.F.J., O'Connell, B., Brown, C., Guinan, J.C. & Grehan, A.J. 2007. Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope". Marine Geodesy, vol. 30, no. 1-2, pp. 3-35.
3. Trevisani S., Teza G., Guth P.L., 2023 (Preprint). Hacking the topographic ruggedness index. 10.5281/zenodo.7716785

Examples

```
dem=rast(paste(system.file("extdata", package = "SurfRough"), "/trento1.tif",sep=""))
w <- matrix(1, nrow=5, ncol=5)
roughTrik5x5=focal(dem, w=w, fun=Trik2)
plot(roughTrik5x5)
```

Index