r.roughness – A new tool for morphometric analysis in GRASS-GIS

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This article briefly describes `r.roughness`, a shell script written to calculate the surface roughness of raster surfaces.

The method is based on Hobson (1972), where roughness is defined as the ratio between surface and plan area of square cells. This script will create square sub-regions with size defined by the user; in each sub-region, the real and planar areas will be calculated by `r.surf.area`, and the results (points at the centre of sub-regions) will be interpolated with `v.surf.rst`. The user also can set the tension and smooth parameters of interpolation.

Surface roughness

Surface roughness (or topographical roughness) was first introduced as a morphometric parameter by Stone and Dugundji (1965) and Hobson (1967, 1972). To Hobson (1972), one possible way to calculate it is the ratio between surface (real) area and flat (plan) area of square cells; in this approach, flat surfaces would present values close to 1, whilst in irregular ones the ratio shows a curvilinear relationship which asymptotically approaches infinity as the real areas increases.

Day (1979) describes surface roughness as the expression of non-systematic variability of the topographic surface, and used the dispersion of vector normals to surface plans as a roughness indicator to discriminate tropical karst stiles.

Ferrari *et al.* (1998) argue that surfaces with distinct characteristics can present the same roughness value, due to the existence of interactions between the number

Fig. 2: Surface roughness map, grid=500m

and magnitude of terrain irregularities. Grohmann (2004), considers this method useful for morphological characterisation since it is mainly related with the shape of land-forms and not its elevation; thus, tectonically tilted areas have their expression shown, while it could be masked in a hypsometric map, as a consequence of altimetric variations.

The method has been applied in studies related to morphology of lake bottoms (Hakanson, 1974), as a discriminant of karstic areas (Day, 1979; Karmann *et al.*, 1996; Ferrari *et al.*, 1998), for structural compartmentation of sedimentary basins basement (Grohmann *et al.*, 2005), in morphometric analysis of alkaline massifs (Roldan *et al.*, 2006; Grohmann *et al.*, 2007), in structural analysis of strike-slip shear zones (Steiner *et al.*, 2006) and for macro-geomorphological compartmentation (Grohmann and Riccomini, 2006).

Usage and examples

The script has five options: `map`, `grid`, `rough`, `tension` and `smooth`. `map` stands for the input raster surface and is the only required option. `grid` is the size of the sub-regions in which roughness will be calculated; the default value is 1000 m. `rough` is the name for the output map; if a name is not provided, it will be set to `input_map_name.roughness.grid_size`. `tension` and `smooth` will be used by `v.surf.rst` for interpolation of

Fig. 1: DEM of study area.

roughness values; the default values are tension=40 and smooth=0.1.

The examples presented are from an area located in south-eastern Brazil, southern region of São Paulo State. Local geology consists of NE-SW trending metapelitic and metacalcareous rocks where karstic landscapes developed over the carbonatic rocks, with altimetric differences up to 700 m between non-carbonatic (pelitic, psamitic and granitic) crests and karstic valley bottoms. NW-SE trending dikes cut across the area and have a strong influence on geomorphological development (Fig. 1). Surface roughness was calculated for grid sizes of 500, 1000 and 2000 m.

With a grid size of 500 m (Fig. 2), a good correlation with land-forms can be seen. Higher roughness values are related with the Bethary River valley, developed over a NW-SE trending dike. Also, karstic valleys have smaller roughness values than non-carbonatic crests. The general picture of the features present in (Fig. 2) can be seen in the map for grid size of 1000 m (Fig. 3), although is not possible to individualise the answer from each carbonatic unit. A grid of 2000 m (Fig. 4) does not give much information, indicating that land-forms within this area cannot be well described with a wavelength this large.

Concluding remarks

Surface roughness is a useful parameter for morphological compartmentation. `r.roughness` is a shell script that automises the process, but users must be aware that it uses `r.surf.area` to calculate both real and planar area for each grid cell (sub-regions) and that raster resolution plays an important role on area estimations.

The script is available through GRASS Wiki site (http://grass.gdf-hannover.de/wiki/GRASS_AddOns) in two versions: `r.roughness` for GRASS 6.1+ and `r.roughness60` for GRASS 6.0.x.

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References

- [1] MJ Day: Surface roughness as a discriminator of tropical karst styles, *Zeitschrift für Geomorphologie*, Suppl.-Bd. 32, pp 1-8, 1979
- [2] JA Ferrari, ST Hiruma, E Antonietti and I Karmann: Geoprocessamento aplicado à caracterização morfométrica de terrenos cársticos - Núcleo Caboclos (PETAR). In: VII Simpósio de Quantificação em Geociências, *Boletim de Resumos Expandidos*: pp 37-40, 1997.
- [3] CH Grohmann: Morphometric analysis in Geographic Information Systems: applications of free software GRASS and R, *Computers & Geosciences*, 30, pp 1055-1067, 2004.
- [4] CH Grohmann, C Riccomini, F Paula e Silva and HK Chang: Compartimentação tectônica da Bacia Bauru no centro-oeste do Estado de São Paulo. X Simpósio Nacional de Estudos Tectônicos / IV International Symposium on Tectonics, Curitiba, 2005, *Boletim de Resumos Expandidos*: pp 25-27, 2005.
- [5] CH Grohmann and C Riccomini: Análise regional de rugosidade de relevo XLIII Congresso Brasileiro de Geologia, Aracaju-SE, *Anais*: p 97, 2006.
- [6] CH Grohmann, C Riccomini, and FM Alves: SRTM-based morphotectonic analysis of the Pocos de Caldas Alkaline Massif, southeastern Brazil, *Computers & Geosciences*, 33: pp 10-19, 2007.
- [7] LA Hakanson: Mathematical model for establishing numerical values of topographical roughness for lake bottoms, *Geografiska Annaler. Series A, Physical Geography*, 56, pp 183-200, 1974.
- [8] RD Hobson: FORTRAN IV programs to determine the surface roughness in topography for the CDC 3400 computer, *Computer Contribution 14*, State Geol. Survey Kansas: pp 1-28, 1967.
- [9] RD Hobson: Surface roughness in topography: quantitative approach. In: Chorley, R.J. (ed) *Spatial analysis in geomorphology*. Methuen, London, pp 225-245, 1972.
- [10] I Karmann, RF Pereira, and JA Ferrari: Índice de rugosidade: parâmetro morfométrico da intensidade de relevo. Exemplo do carste da bacia do Rio Una, Bahia. In: XXXIX Congresso Brasileiro de Geologia, Salvador, *Anais*: pp 575-579, 1996.
- [11] LF Roldan, SS Steiner, CH Grohmann and R Machado: Análise morfométrica da região do Domo de Lages, SC. XLIII Congresso Brasileiro de Geologia, Aracaju-SE, *Anais*: p 266, 2006.
- [12] SS Steiner, R Machado, and CH Grohmann: Análise morfométrica da estrutura divergente na região do Rio Paraíba do Sul, Rio de Janeiro. XLIII Congresso Brasileiro de Geologia, Aracaju-SE, *Anais*: p 97, 2006.
- [13] RO Stone and J Dugundji: A study of microrelief - its mapping, classification and quantification by means of a Fourier analysis, *Engineering Geology*, 1: pp 89-187, 1965.

Fig. 3: Surface roughness map, grid=1000 m

Fig. 4: Surface roughness map, grid=2000 m