Implementing the automatic extraction of ridge and valley axes using the PPA aglorithm in Grass GIS

Yet-Chung Chang†, Alessandro Frigeri ††

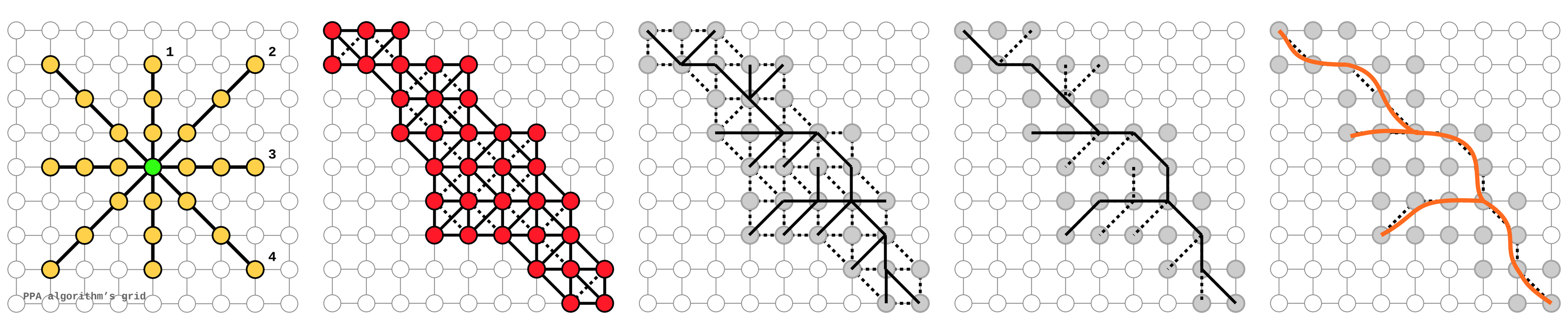
† Department of the Network & Communication Engineering, Diwan College of Management
No.87-1, Nanshi Li, Madou Jen, Tainan, Taiwan, R.O.C.
e-mail: ycchang@mail.dwu.edu.tw
† Coastal Ocean Monitoring Center, National Cheng Kung University, No.1 Ta-Hsueh Road, Tainan,Taiwan 701, R.O.C.
web site: http://www.comc.ncku.edu.tw

†† Dipartimento di Scienze della Terra, Geologia Strutturale e Geofisica,
Universitá degli Studi di Perugia, P.zza Universita 1, 06100 Perugia, ITALY.
e-mail: afrigeri@unipg.it

Introduction

The automatic extraction techniques of linear or curvilinear features from 2-dimensional maps have been in great demand by many map interpreters for decades. In 1990s, some algorithms had been developed under this demand [2, 4, 5]. The two remaining problems of this issue are: 1) how to keep the linear features be continuous when the targets are occasionally vague, and 2) how to handle the complicate branch lines properly and completely. In this task, we prove that Profile recognition and Polygon breaking Algorithm (PPA), which was developed by Chang et al. [1], can solve these two problems quite properly and reasonably.

The PPA algorithm



(A) (B) (C) (D) (E)

A - Profile Recognition Algorithm: A possible target point of ridge axis (green circle) is made centre of a variable length profile (yellow circles) of profile switched in all the possible directions (1,2,3,4). The point is a target if at least a lower point along a profile is found.

B - Target Connection Process: It will register each target's (red circles) connection state with its 8 neighbours in the grid. When a segment crosses another, the less important segment, like a lower elevation segment in the case of ridge extraction, is cancelled (dotted segments).

C - Polygon Breaking Process: The polygons are broken into dendritic line patterns by repeatedly eliminating (dotted segments) the least important segment among each closed polygon (the lowest one in the case of ridge recognition).

D - Branch Reduction Process: It eliminates ambiguous or unimportant ends of complex branches (dotted segments).

E - Line Smoothing Process: It softens the angles of segments' connection. It is basically a position interpolation process based on elevation. Its effect is evident especially when grid intervals are large.

The `r.ppa` module

The map in Figure 1 represents a portion of Digital Elevation Model (DEM) coming from the freely available Spearfish dataset[1]. The projection is UTM zone 13 and the reference ellipsoid is WGS84. The Dem resolution is 30 meters. The region displayed is dimensioned so to have a 95x115 bidimensional dataset. The elevation range is from 1223 meters (brightest green) to 1559 meters (darkest brown). Isolines with an equidistance of 25 meters are reported in brown while for the black isolines equidistance is 100 meters.

Calling `r.ppa` module within Grass GIS environment will ask the user for raster map to be analysed, the vector file to be generated and the specific PPA parameters: the type of analysis (the extraction of valleys or ridges axes), the algorithm grid resolution, and the profile length (in number of points on the algorithm's grid).

The extraction of ridges axis is shown in Figure 2. The DEM is overlayed by `r.ppa` vector output (in yellow) obtained on a 100x100 meters grid (the grey grid) with a profile length of 5. Analysis is made on a wider (about half the profile length will suffice) region to avoid influence of DEM's boundaries.

Varying the parameters brings different results, a good combination in the case of the study area is to get a 50x50 grid and a profile length of 10. The yellow vectors in Figure 3 are the results of automatic extraction of ridge axis. Figure 4 shows the extraction of valley axes (white vectors) with the same parameters used above.

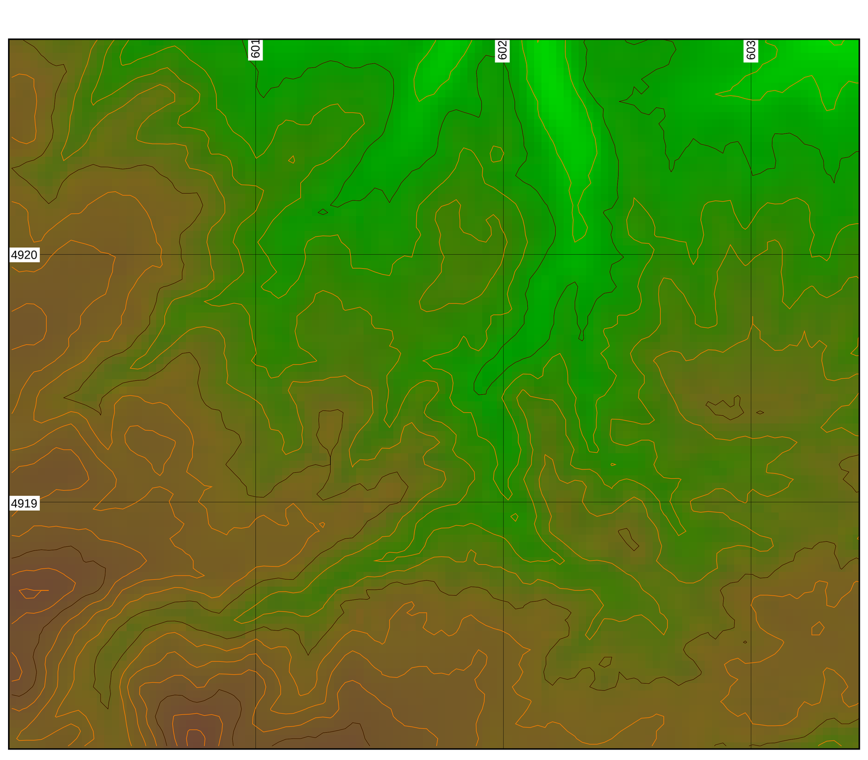


Figure 1: DEM from a subregion of Spearfish dataset. UTM coordinates are reported in chilometers.

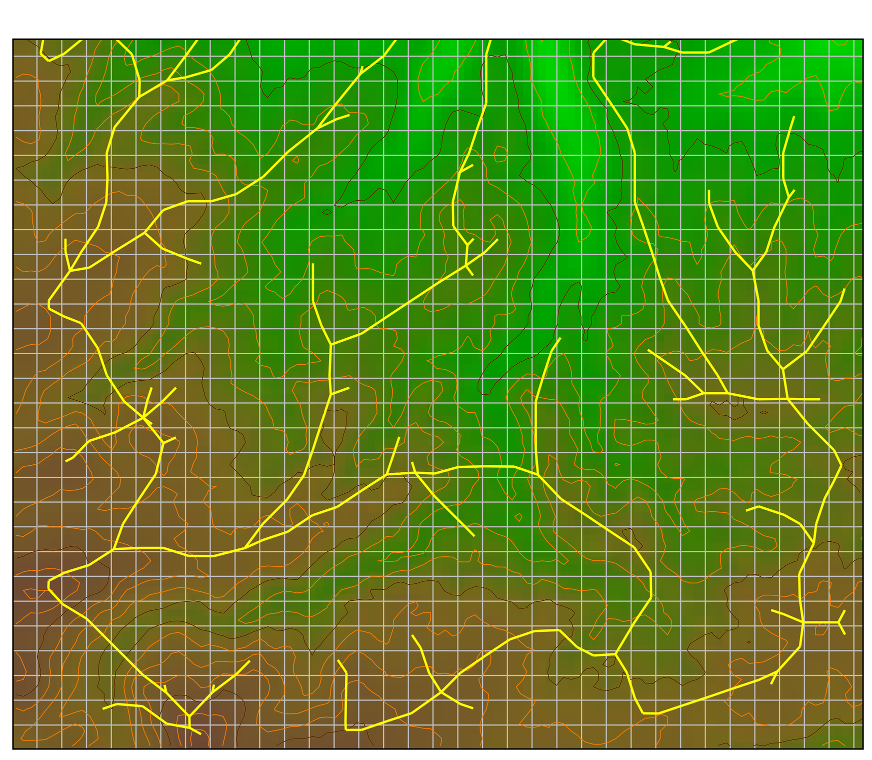


Figure 2: The PPA algorithm applied to Spearfish DEM

Conclusions

The ppa algorithm is so included in Grass GIS through `r.ppa` module. The original Fortran source code has not been modified apart for `IO` and to get command line arguments.

At the moment the module is fully functional, so, after the creation of a manual page, it could be distributed internally of Grass or as external module.

Though `f2c` produces a working C version of the code, manual translation is needed to maintain good code readability. In the C version there will be the opportunity to call Grass raster libraries directly form the code.

Although the PPA is used only for ridge and valley axes extraction in this paper, it is also possible to apply on many other kinds of linear features.

The key point is how to define the target point in the Profile Recognition Process. For example, on a satellite image, the color contrast between the sea and land can be used as parameters or formula to define targets, therefore to delineate the shorelines.

Some of such works have been done by the author Chang in Taiwan, including the lineation of continental shelf breaks, shorelines picking and seismic skeleton of the Ground Penetration Radar (GPR) profiles.

[1] Spearfish dataset together with other free data sources is available at `http://grass.itc.it/data.html` Grass site or other Grass mirror site

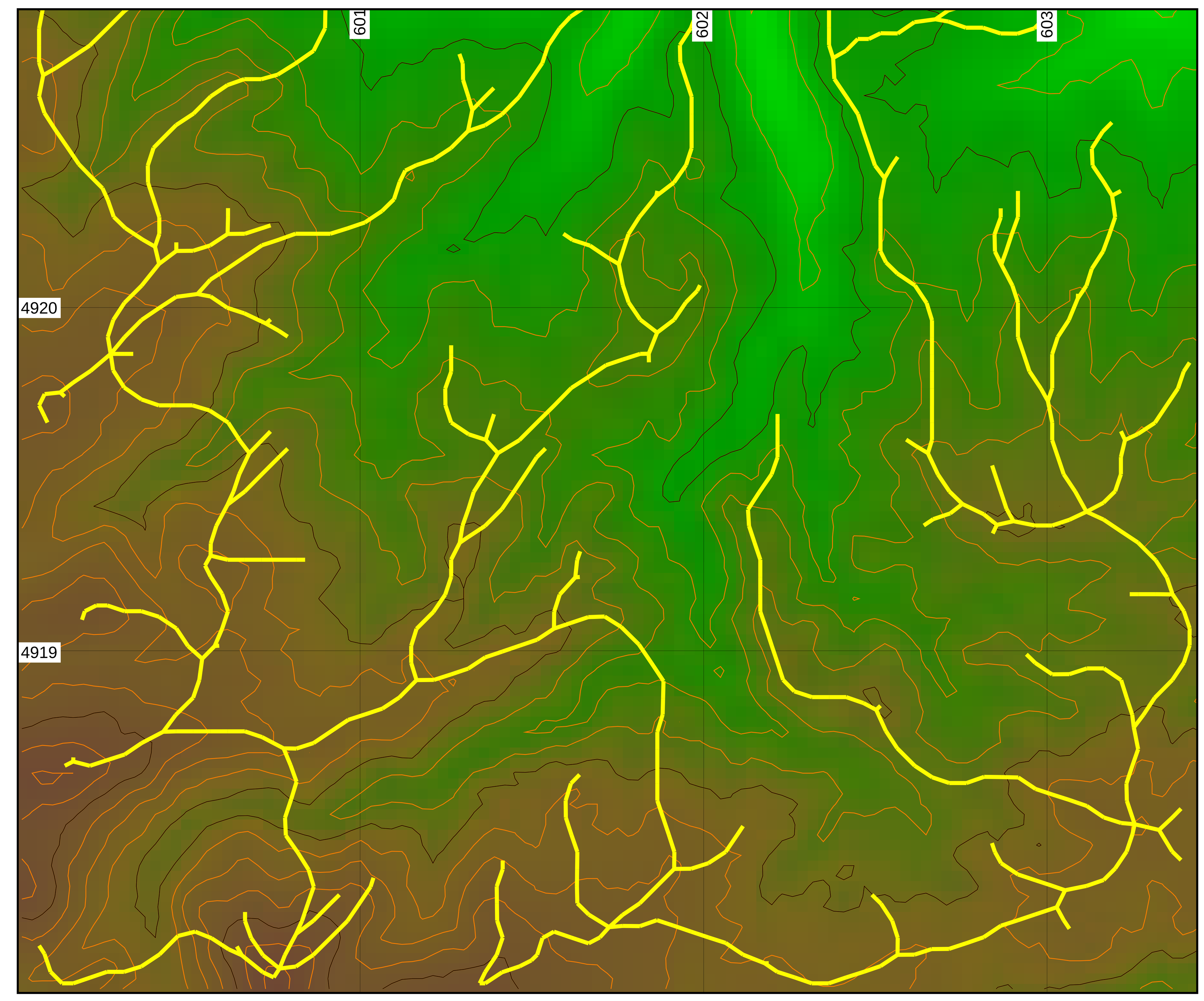


Figure 3: Automatic extraction of ridge axis using a 50x50 grid and a profile length of 10.

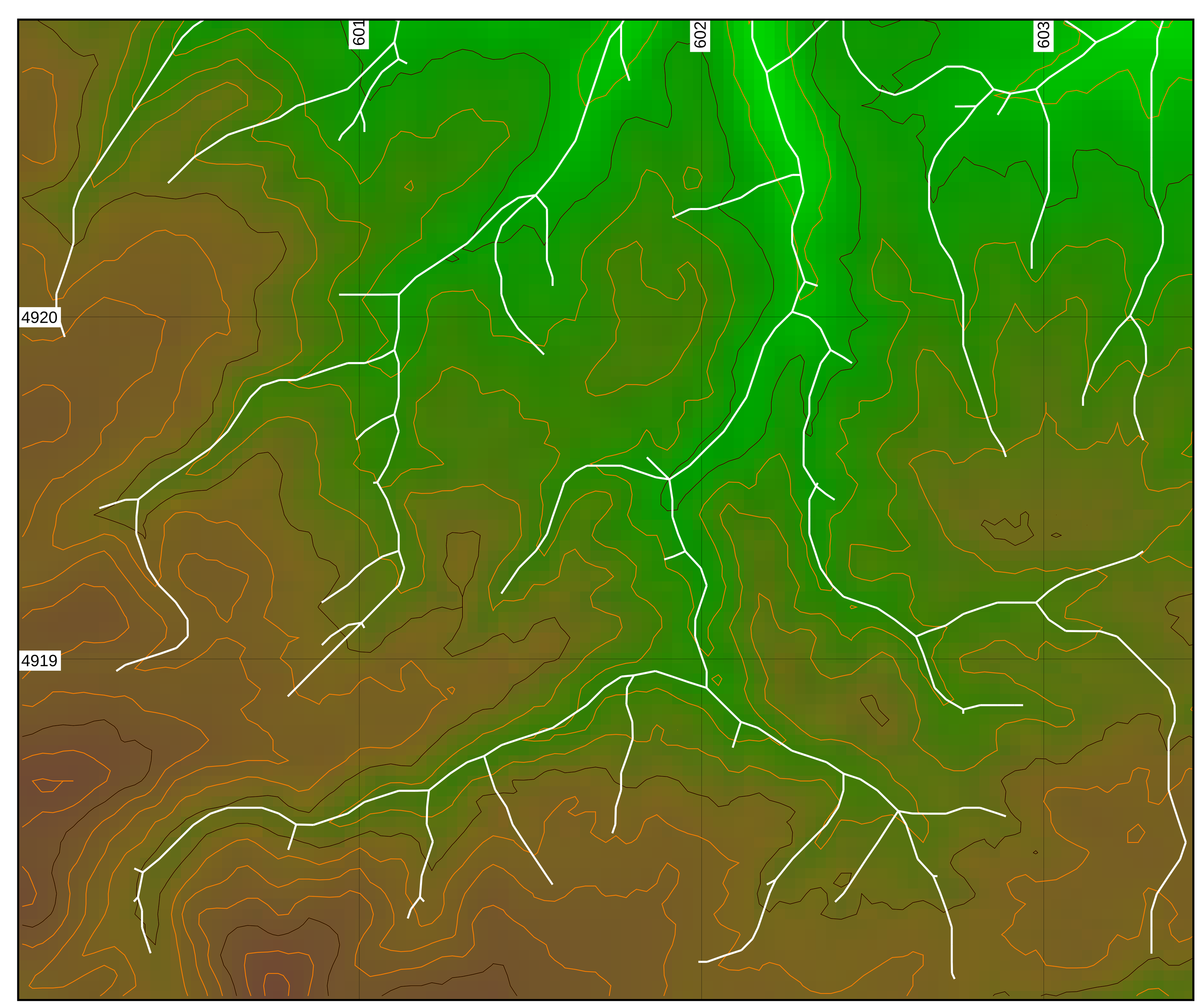


Figure 4: Automatic extraction of valley axis using a 50x50 grid and a profile length of 10.

Future development are up to the Grass users needs. Since ppa algotithm treats heights, it would be very interesting to make `r.ppa` supporting the creation of 3D vector layers that are being implemented in Grass v.5.1 and will be available in the future stable releases as Grass v.5.2.

Feedback on the algorithm and the Grass implementation will be very apreciated by the authors, that look forward to see if and how `r.ppa` will help in solving specific scientific problems.

References

[1] Y.C. Chang, S.K. Hsu, and G.S. Song. Automatic extraction of ridge and valley axes using the profile recognition and polygon breaking algorithm. *Computers & Geosciences*, 24(1):83–93, 1998.

[2] J. Chorowitz, C. Ichoko, S. Riazanoff, and Y.J. Kim. A combined algorithm for automated drainage network extraction. *Water Resource Research*, 28:1293–1302, 1992.

[3] Grass Documentation Project. *GRASS 5 Programmer's Manual*. http://grass.itc.it/grassdevel.html, April 2002.

[4] K. Koike, S. Nagano, and O. Michito. Lineament analysis of satellite images using a segment tracing algorithm. *Computers & Geosciences*, 21(9):1091–1104, 1995.

[5] S.Y. Lu and Y.C. Cheng. An iterative approach to seismic skeletonization. *Geophysics*, 55(10):1312–1320, 1990.