Processing UAV and lidar point clouds in GRASS GIS

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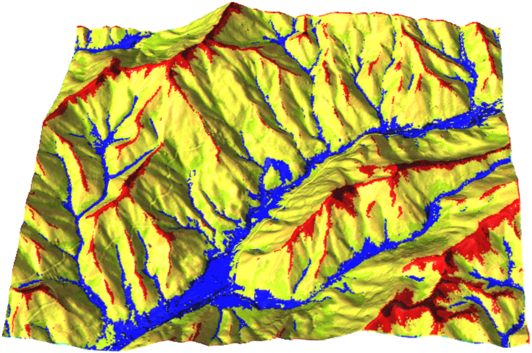
Providing algorithms to the community

- new landform recognition approach – geomorphons
- by Jasiewicz and Stepinski from AMU, Poland and University of Cincinnati, USA
- not just a paper

  Geomorphology, 2013
- not just public code
- *r.geomorphon*

  module in GRASS GIS addons repository



Free, libre and open source

Scripts and code I'm writing

- review
- re-usable
    - by other people
    - by future myself

Software I'm using

- driven by needs of users
- longevity
    - learn now, use forever
    - GRASS GIS: over 30 years of development

Open Science Logo, Greg Emmerich, CC BY-SA 2.0

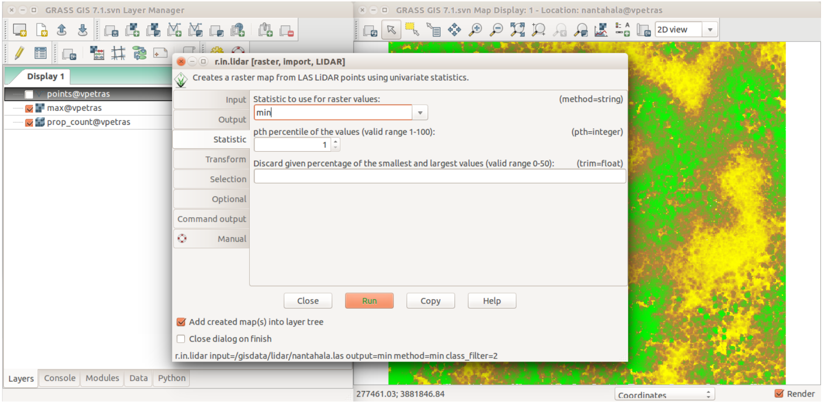
GRASS GIS

- all in one
  - hydrology modeling, image segmentation, point clustering, ...
- from small laptops to supercomputers
  - Raspberry Pi, Windows, Mac, GNU/Linux, FreeBSD, IBM AIX
- learn now, use forever
  - over 30 years of development and interface refinement
- used by
  - US Oak Ridge National Laboratory, Edmund Mach Foundation, JRC, ...

latest release 7.0.4

Sunday, May 1, 2016

GUI


GRASS GIS 7.1.svn Layer Manager
GRASS GIS 7.1.svn Map Display: 1 - Location: nantahala@vpetras
2D view
Display 1
points@vpetras
max@vpetras
prop_count@vpetras
r.in.lidar [raster, import, LIDAR]
Creates a raster map from LAS LiDAR points using univariate statistics.
Input
Output
Statistic
Transform
Selection
Optional
Command output
Manual
Statistic to use for raster values:
(method=string)
min
pth percentile of the values (valid range 1-100):
(pth=integer)
1
Discard given percentage of the smallest and largest values (valid range 0-50):
(trim=float)
Close
Run
Copy
Help
Add created map(s) into layer tree
Close dialog on finish
r.in.lidar input=/gisdata/lidar/nantahala.las output=min method=min class_filter=2
Layers
Console
Modules
Data
Python
277461.03; 3881846.84
Coordinates
Render

Python and command line interfaces

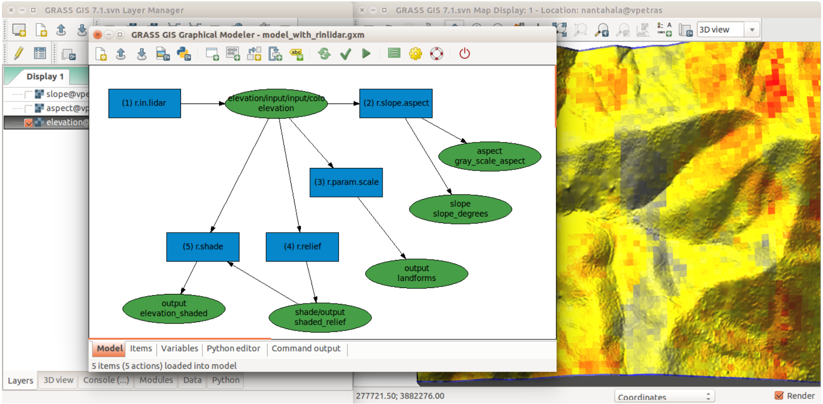
Documentation, Command Line (Shell, Bash, cmd.exe):

```
r.in.lidar input=points.las \
           output=elevation -e
```

Python:

```
from grass.script import run_command
run_command('r.in.lidar',
            input="points.las",
            output="elevation",
            flags='e')
```

Graphical Modeler

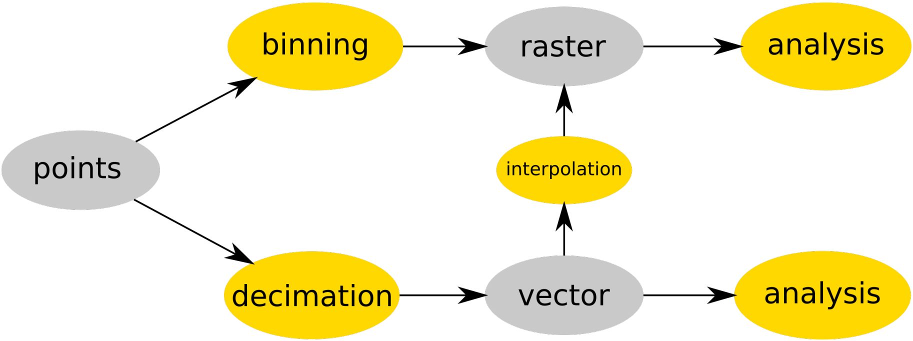


Points

- collected by lidar
- generated by Structure from Motion (SfM) from UAV imagery

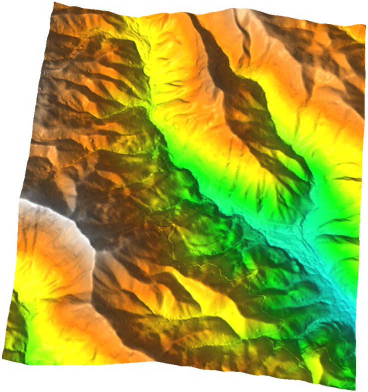
surface interpolated from points and visualized in GRASS GIS

Workflow overview



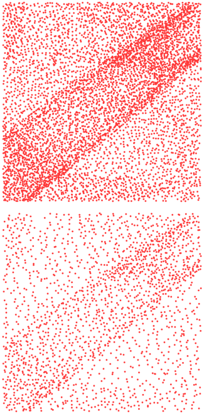
Surface interpolation

- *v.surf.idw*
  - Inverse Distance squared Weighting
- *v.surf.bspline*
  - Bicubic or bilinear Spline interpolation with Tykhonov regularization
- *v.surf.rst*
  - Regularized Spline with Tension
  - *v.surf.rst.mp* (experimental)
    - 2 millions of points in 11 minutes



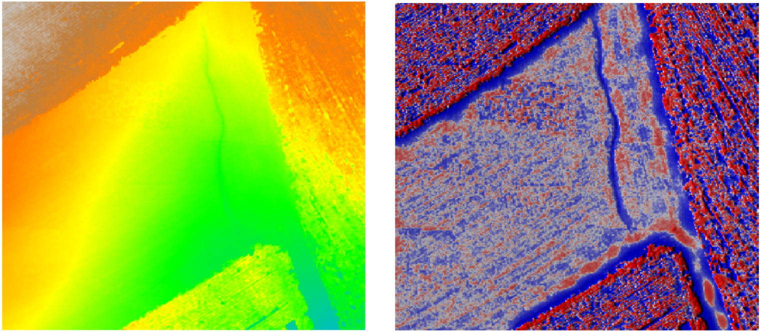
Import and decimation

- *v.in.lidar*
  - libLAS
  - LAS/LAZ to GRASS GIS native vector
  - data stored in GRASS GIS database
- interpolation, clustering, ... are costly
- often more points than we need
- decimation ≈ thinning ≈ sampling
  - count-based decimation (skips points)
  - grid-based experimental, others needed?
  - fast count-based as good as more advanced decimations



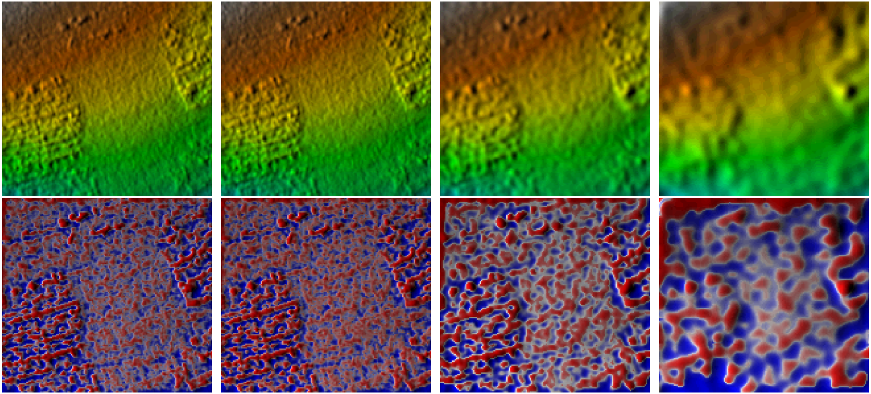
Local relief model (LRM)

- *r.local.relief* (micro-topography, features other than trend)



30-60cm wide, 30cm deep, 60m long gully (resolution 30cm)

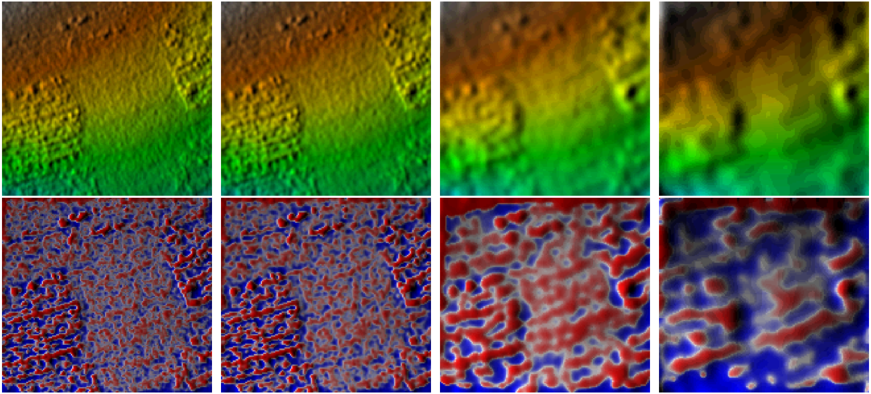
Count-based decimation influence on interpolated elevation



keep all	skip every 5	keep every 20	keep every 100
0 %	20 %	90 %	99 %

test data (not used in the study)

Influence of grid-based decimation resolution



grid size 0.1 m
0 %

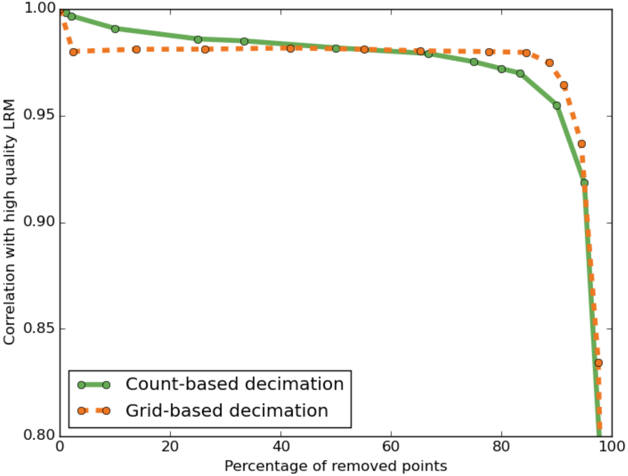
grid size 0.3 m
81 %

grid size 0.9 m
98 %

grid size 1.5 m
99 %

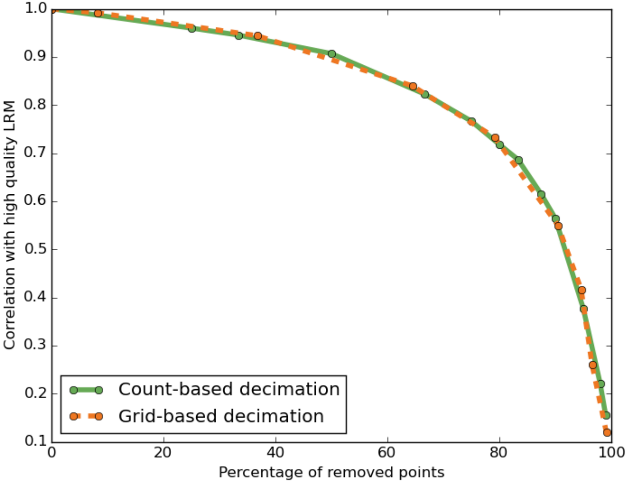
test data (not used in the study)

Decimating UAV/SfM point cloud



interpolations and local relief model computations at resolution 0.5 m 72 point per 1 m^2

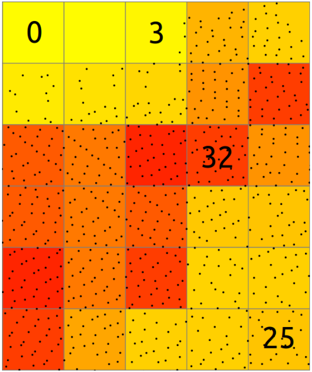
Decimating lidar point cloud



interpolations and local relief model computations at resolution 0.5 m 1 point per 1 m^2

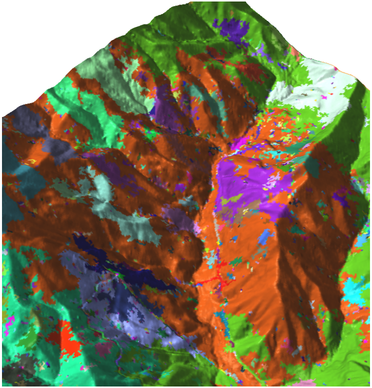
Binning points to raster

- *r.in.lidar*
- import and analysis
- statistics of point counts, height and intensity
  - n, min, max, sum
  - mean, range, skewness, ...



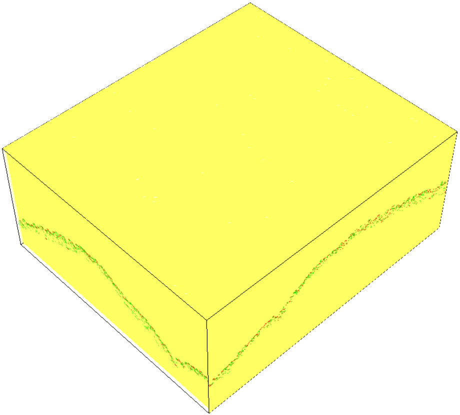
Raster processing

- many algorithms are raster-based
  - 163 raster modules
  - 45 imagery modules
  - 20 spatio-temporal raster modules
- example:
  1. count of ground points
  2. count of non-ground points
  3. used as image bands
  4. segmentation using *i.segment*



3D raster

- stacked 2D rasters
- challenging to visualize
- same principles as in 2D
  - e.g. 3D raster map algebra



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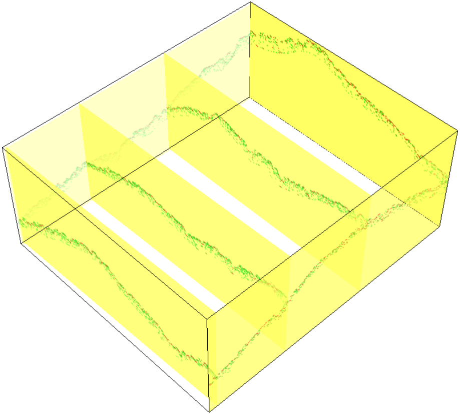
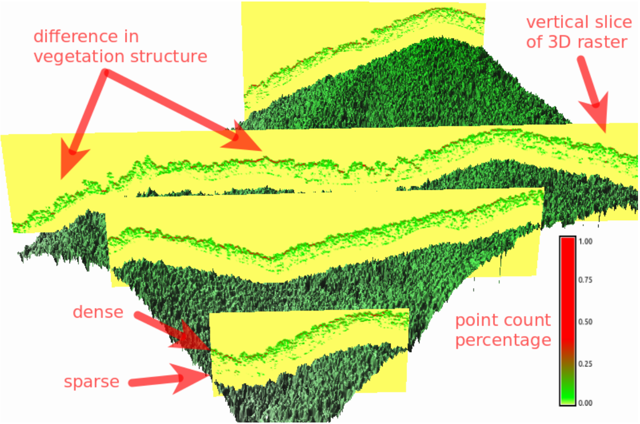
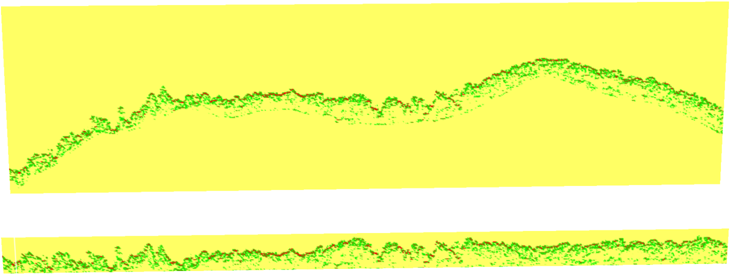


Binning points to 3D raster

- *r3.in.lidar*
- proportional count
  - count per 3D cell relative to the count per vertical column
- intensity can be used instead of count



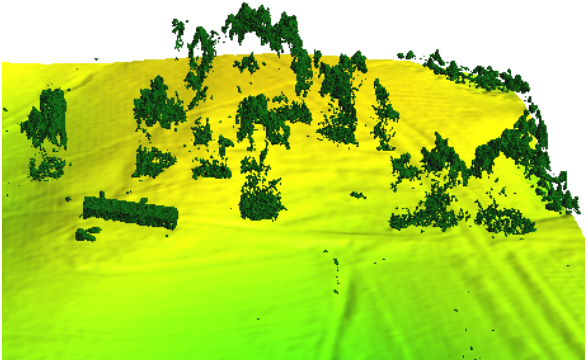
Point heights reduced to surface



- *r3.in.lidar*, option *base_raster*
- height reduced by 2D raster values
- similarly also for 2D binning: height above a surface, top of the canopy, ...

Ground detection

- *v.lidar.edgedetection*, *v.lidar.growing*, *v.lidar.correction*
  - by Brovelli, Cannata, Antolin & Moreno
- *v.lidar.mcc*
  - multiscale curvature based classification algorithm
  - by Blumentrath, according to Evans & Hudak
- PDAL filters.ground
  - currently in v.in.pdal
  - progressive morphological filter by Zhang
  - provided by PCL



Current state of integration with PDAL

PDAL

- Point Data Abstraction Library
- format conversions
- processing, filtering

Experimental integration

- *v.in.pdal*
  - next: *r.in.pdal*, *r3.in.pdal*
- runs PDAL filters during import
  - filters are followed by GRASS processing

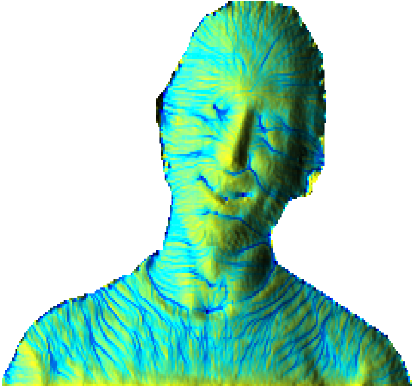
Using other open source projects

r.in.kinect

- scans using Kinect
- OpenKinect libfreenect2
- Point Cloud Library (PCL)
- GRASS GIS libraries
  - C API
  - raster processing
  - regularized spline with tension interpolation

used in
Tangible Landscape

TANGIBLE LANDSCAPE



Summary

- rasterize early
- GRASS modules can work with large data
  - sometimes a special flag is needed
  - if not, report a bug
- 3D rasters, PDAL integration

Get GRASS GIS 7.3 development version at
`grass.osgeo.org/download`

GRASS user mailing list
`lists.osgeo.org/listinfo/grass-user`

Paper and slides available at
`wenzeslaus.github.io/grass-lidar-talks`

Acknowledgements

Software

Presented functionality is work done by Vaclav Petras, Markus Metz, and the GRASS development team.

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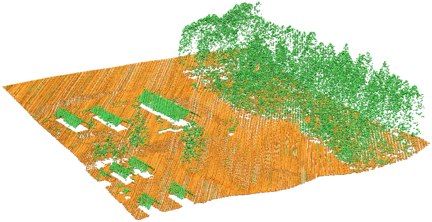
Acknowledgements

Datasets

Lidar and UAV Structure from Motion (SfM) data for GIS595/MEA792: UAV/lidar Data Analytics course

Nantahala NF, NC: Forest Leaf Structure, Terrain and Hydrophysiology. Obtained from OpenTopography.
`http://dx.doi.org/10.5069/G9HT2M76`



Acknowledgements

Presentation software

Slides were created in $\LaTeX$ using the BEAMER *class*.