Faculty of the Built Environment & Architecture

Digital terrain modelling (GEO1015) — 5 ECTS

Location: BK room A
Date & time: 28 January 2022, 09:00–11:30
Responsible teacher: Hugo Ledoux

1. The subject matter is in full accordance with the study guide.
2. This final exam is worth 35% of the final mark for the course.
3. The maximum grade for this course is 10.0. The minimum (unrounded) final mark to pass this course is 5.75, which will be rounded to 6.0. However, you need at least a 50% in the combined exams (midterm + this one) to be able to pass the course.
4. There is 80 points to earn:
   - 10 multiple choice questions [2 points each]. For this section, there is **negative marking**. That is, for each question, if you get it right you get 2pts, if you answer nothing you get 0pt, and if you get it wrong you get -1pt. You cannot get less than 0pts in total for these questions.
   - 10 short answers [6 points each]
5. Answer directly on these pages. If there is not enough space, use extra sheets and staple them at the end.
6. This is an open-book exam, only paper is allowed. No computer/phone/etc; a calculator is fine.
7. This final exam has 20 questions, and 15 pages.
8. Fill out your name and student ID.
9. You have 2h30min to do this exam.

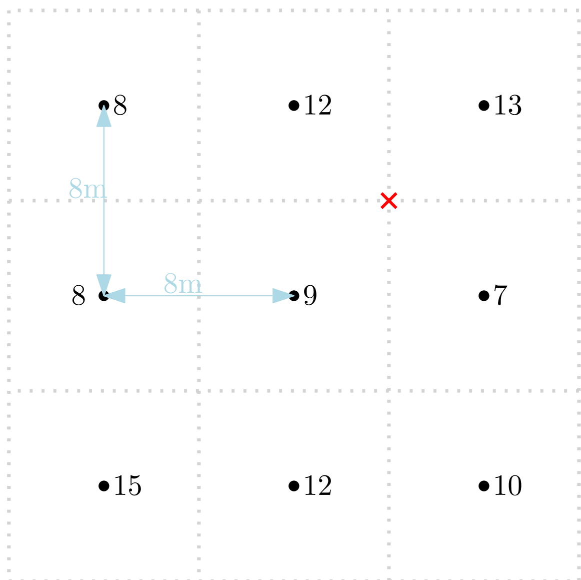
Name: ____

Student ID: _______________________________________

Multiple choice questions (20 points)

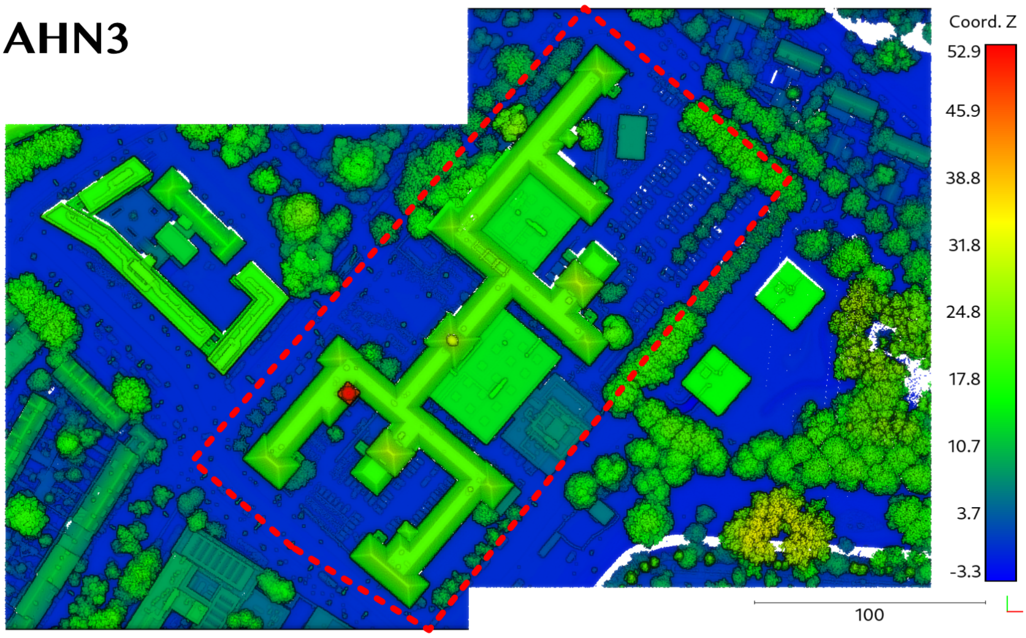
[Only one good answer, unless otherwise stated]

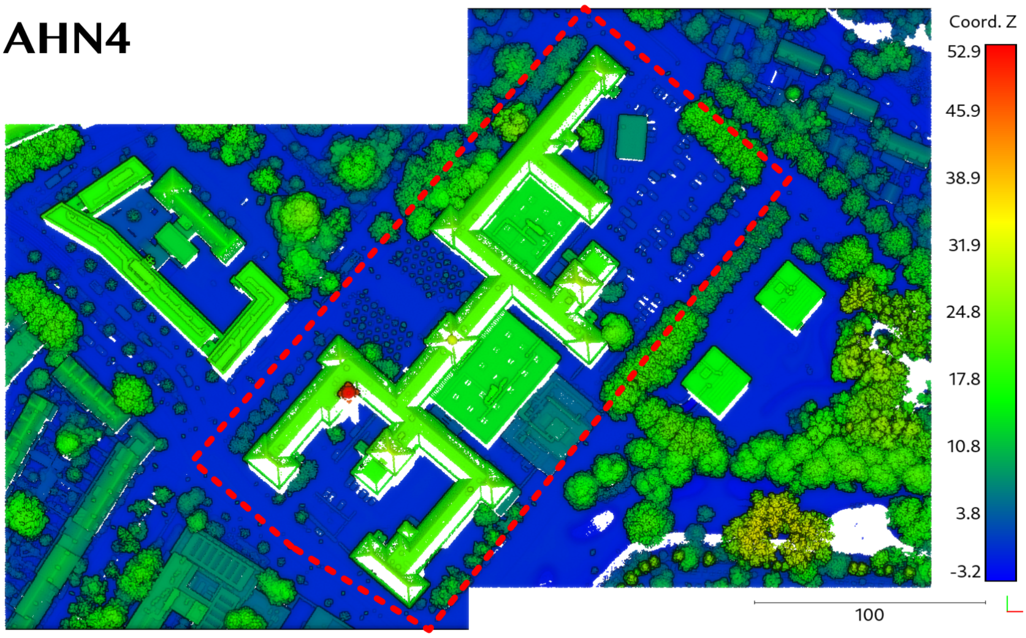
1. (2 points) A C^0 interpolant (a function) is a continuous function whose first derivative is possible at all points.
   - ◯ true
   - ◯ false
2. (2 points) A kd-tree in 2D is a binary tree (every node has 2 children maximum), and in 3D it can have 3 children maximum.
   - ◯ true
   - ◯ false
3. (2 points) Given a Delaunay triangle τ, its dual is:
   - ◯ a Voronoi vertex located at the centre of the circumcircle of τ, which is guaranteed to be located inside τ
   - ◯ a Voronoi polygon formed of all the dual of the vertices of τ
   - ◯ a Voronoi vertex located at the centre of the circumcircle of τ, which could be located outside τ
   - ◯ none of these
4. (2 points) Assume you have the 9 elevation sample points as shown below, those are distributed on a 8mX8m grid. If we interpolate at location x (in red) with (1) Laplace interpolation and (2) IDW with $radius = 10$ and $power = 2$, both estimations will be the same.
   - ◯ true
   - ◯ false



5. (2 points) Below you see a top down view of two point clouds of our faculty building, captured using aerial LiDAR at different times and with different equipment. The colours visualise elevation in meters. The AHN4 point cloud (bottom image) has significant no-data areas (in white). What could have caused the no-data areas in the area marked with red dashed lines? You may assume no outliers have been filtered. *[Multiple correct answers possible!]*

   - ◯ Multi-path effect
   - ◯ Color and/or light absorption properties of roof materials
   - ◯ Occlusion effects
   - ◯ Moving objects between the building and the LiDAR scanner
   - ◯ Wet surfaces at the time of acquisition
   - ◯ Lower overall point density compared to AHN3





6. (2 points) While using kriging to interpolate a set of sample points, you find that the output surface seems to have visible discontinuities. This is a product of:

   - ◯ a large sill
   - ◯ an incorrect theoretical variogram function
   - ◯ noisy input
   - ◯ a small search radius
   - ◯ inherent randonmess in the data

7. (2 points) You want to model runoff in a DTM that appears to have a large and perfectly flat area. Which of the following methods will yield a good result without performing unnecessary steps? *[Multiple correct answers possible!]*

   - ◯ D8
   - ◯ D8, then artificial gradients
   - ◯ LCP
   - ◯ LCP, then artificial gradients
   - ◯ any MFD method

8. (2 points) With the region growing algorithm for plane detection based on the difference of normals as explained in the book you can also detect smoothly curved shapes like a sphere.

   - ◯ true
   - ◯ false

9. (2 points) Fill in the blank: When iteratively applying the bathymetric smoothing operator from Chapter 13, each consecutive iteration leads to ________ elevation change in the TIN surface.

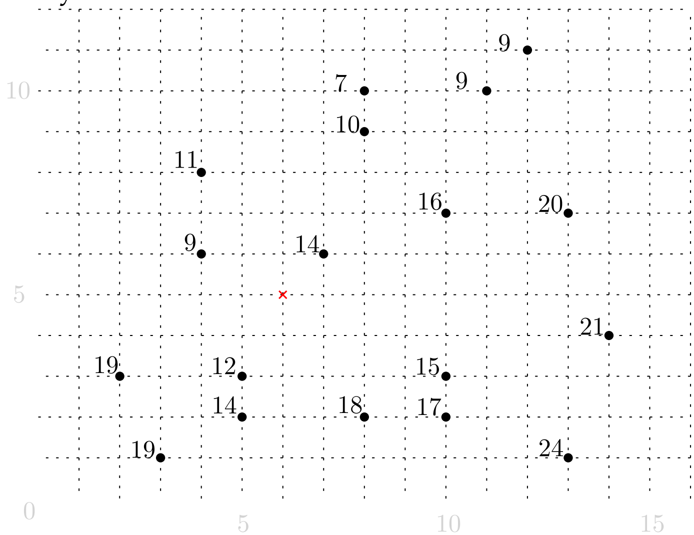
   - ◯ more
   - ◯ less

10. (2 points) In the context of terrains, a TIN is a (Delaunay) triangulation in 2D of the samples points (x, y, z) projected to the xy-plane, and then a surface is obtained by lifting the vertices to their original z position.

    - ◯ true
    - ◯ false

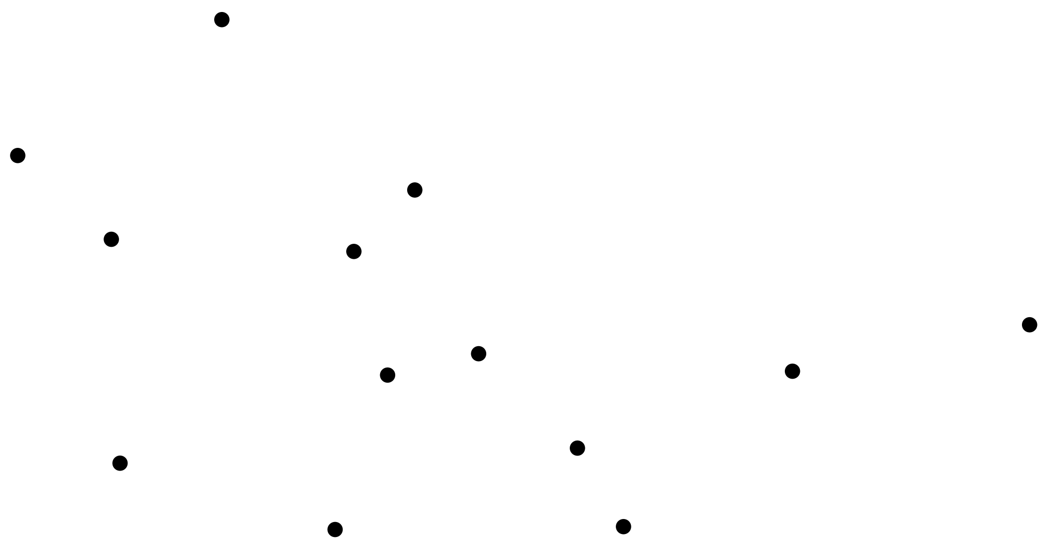
Short answer questions (60 points)

11. (6 points) Estimate the elevation at location (6, 5) (the red cross) with the IDW variant k-per-quadrant; knowing that $k = 1$, $power = 2$, and $radius = 10$. Describe the formulas and your calculations.

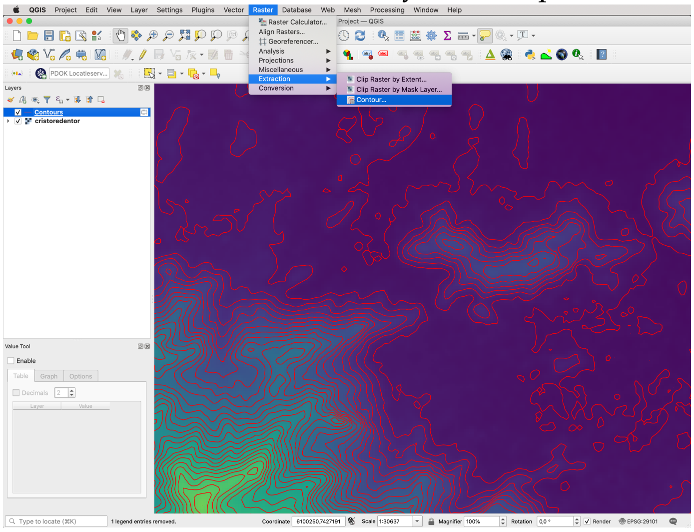


12. (6 points) The streaming paradigm to create the Delaunay triangulation of massive point clouds datasets might not work in certain cases. Name one such case, and give a *detailed* description (with a drawing) of why and how it would fail.

13. (6 points) For the set of points below, (1) draw its convex hull, and (2) draw its Voronoi diagram (an approximation is fine). In different colours if possible.



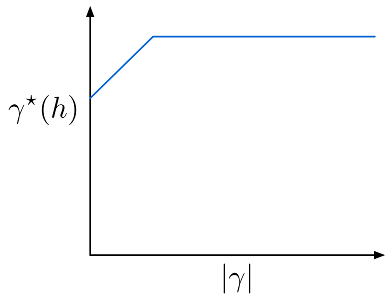
14. (6 points) You are asked to create isolines of the gridded AHN3 file below. You use QGIS/GDAL functions to extract the isolines at every 2m and you obtain those lines: not very smooth and several unconnected components. Describe a methodology that you could apply to the data to improve the output isolines. The description should be at a higher level and speak in terms of algorithms and/or methods you learned during the course, not in terms of buttons you could press in QGIS.

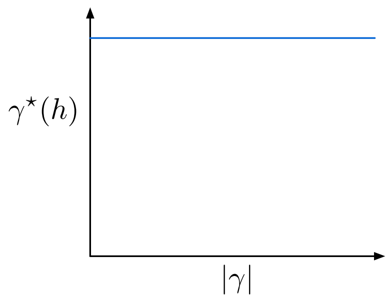


15. (6 points) We know the slope for a given location (x, y): its gradient (α) is 22° and its aspect (θ) is 45°. Draw the (hypothetical) isolines for the area surrounding this location, and identify clearly where that point would be. An estimation and guessing of the surrounding is fine.

16. (6 points) Starting from your implementation of LCP in the homework assignment, what extra steps would you need to add to find the number of different basins in your chosen map?

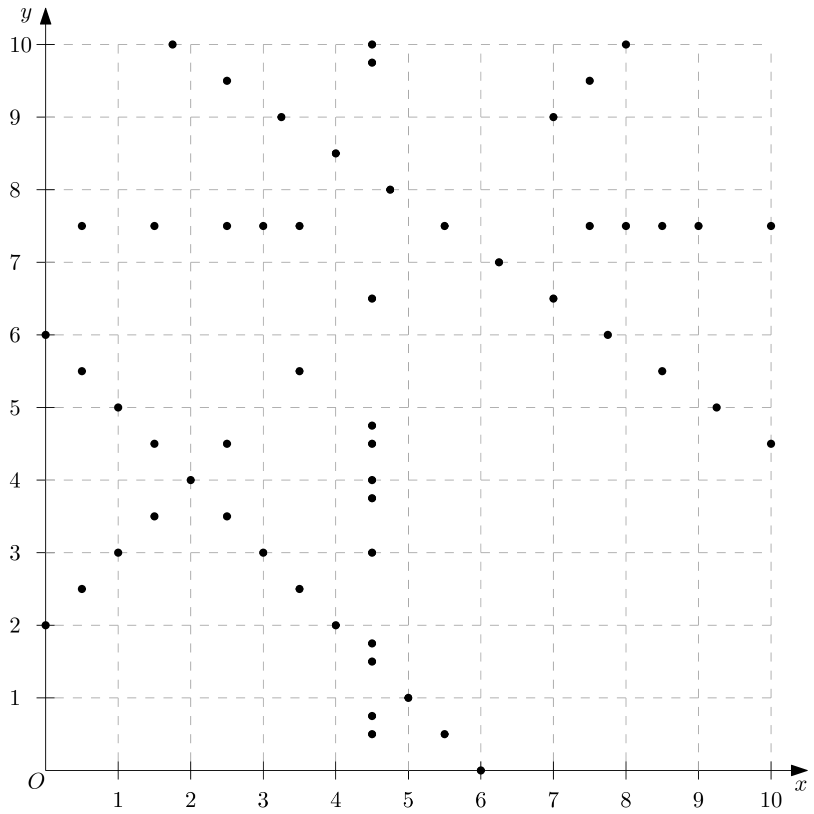
17. (6 points) Describe a dataset that would result in each of the following variograms (3pts each)





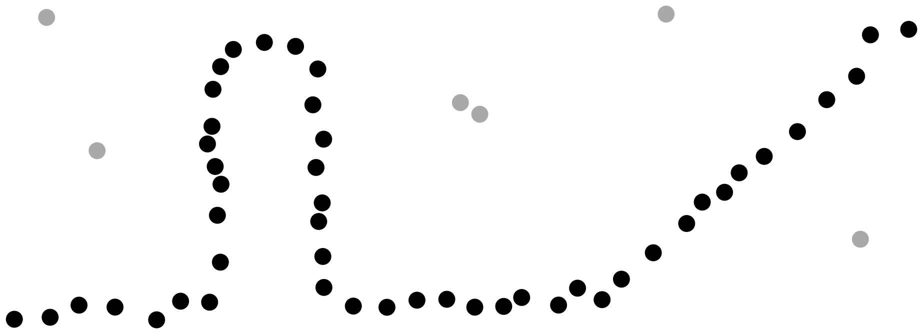
18. (6 points) There are 2 algorithms described in the book for TIN simplification: refinement and decimation. Which one do you think would be faster (in terms of operations performed) for a lidar dataset (about 20pts/m^2) for a very hilly region, where we have a large threshold for simplification (say 5m of error is allowed).

19. (6 points) Below a 2D point cloud is given that contains a number of lines. Apply the Hough transform algorithm by filling out the accumulator matrix given below. How many lines would be detected if the minimum number of votes is 10? The Hesse normal form is used to parametrise the lines ($r = x\cos\phi + y\sin\phi$).



$r \setminus \phi$	0°	45°	90°	135°
0				
$\sqrt{2}$				
$1\frac{1}{2}$				
3				
$3\sqrt{2}$				
$4\frac{1}{2}$				
$7\frac{1}{2}$				
$6\sqrt{2}$				

20. (6 points) The point cloud depicted below has a few outliers drawn in grey. Explain in details one algorithm that can be used to automatically remove these. Use the figure to illustrate.



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