TU Delft Delft University of Technology

Faculty of the Built Environment & Architecture

Digital terrain modelling (GEO1015) — 5 ECTS

26 January 2024, 09:00–11:30
Location: 34.D–1–200
Responsible teacher: Hugo Ledoux

1. The subject matter is in full accordance with the study guide.
2. This final exam is worth 50% 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 57.5%, 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 are 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 14 pages.
8. Fill out your name and student ID.
9. You have 2h30min to do this exam.

Name: _____

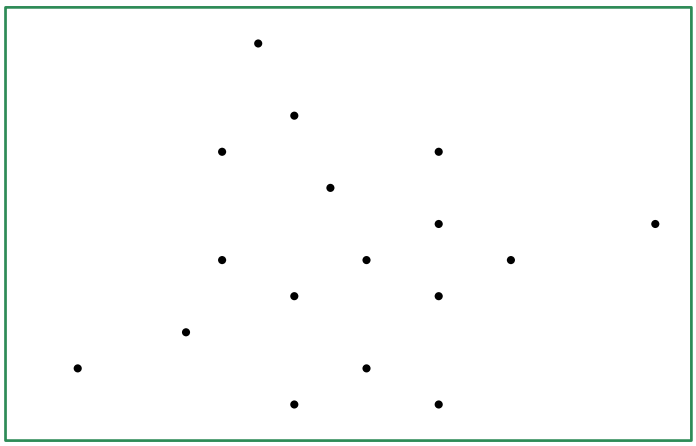
Student ID: _____

Multiple choice questions (20 points)

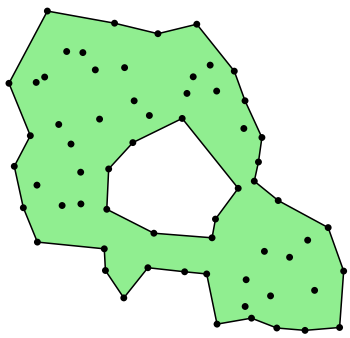
[Only one good answer for each question]

1. (2 points) You have 2 gridded datasets for an area, and for one xy-location both values for the DSM and the nDSM are exactly the same. Where is this dataset most likely from?
   - ◯ Delft, the Netherlands
   - ◯ Zürich, Switzerland
   - ◯ it's impossible to have the same value for a DSM and a nDSM

2. (2 points) How many triangles will the Delaunay triangulation of this 17-point dataset contain?
   - ◯ 27
   - ◯ 29
   - ◯ 34
   - ◯ impossible to calculate I would need to know the exact distances between those points



3. (2 points) Which spatial extent algorithm was most likely used for this dataset?
   - ◯ convex hull
   - ◯ χ-shape
   - ◯ α-shape
   - ◯ impossible to conclude based on the information shown here



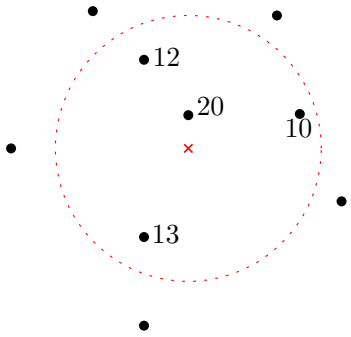
4. (2 points) In a LAS file the coordinates of each points are stored with floats/doubles, but in a LAZ files with integers.
   - ◯ true
   - ◯ false

5. (2 points) The TIN refinement ground filter algorithm you used in hw04 is not affected by the presence of outliers in the datasets because it can remove them with its 2 parameters.
   - ◯ true
   - ◯ false

6. (2 points) When modelling a theoretical variogram function, what could a small range represent?
   - ◯ a dataset with a lot of noise
   - ◯ a dataset with a small bulge in the middle
   - ◯ a dataset with limited spatial correlation
   - ◯ a dataset with a continuous slope

7. (2 points) Fill in the blank: When applying the bathymetric smoothing operator from Chapter 14, each iteration moves _____ the vertices of the TIN.
   - ◯ upwards, if at all
   - ◯ downwards, if at all
   - ◯ downwards or upwards, it depends on the configuration of the neighbours

8. (2 points) You perform twice the standard IDW interpolation at the location of the red cross, for both you keep the same radius (shown in red). Which power will yield a higher estimated value?
   - ◯ power=1.5
   - ◯ power=2.0



9. (2 points) When is bilinear interpolation used in the context of modelling terrains?
   - ◯ when the input is a TIN
   - ◯ when the input is a grid raster
   - ◯ when there are 2 dependent values to (x, y), eg elevation and time

10. (2 points) In the context of this course, a triangulated irregular network (TIN) is:

    ◯ a piecewise tessellation of the plane into irregular cells where a linear function is used to estimate the elevation

    ◯ a hierarchical tessellation of the plane space into triangles where a linear function is used to estimate the elevation

    ◯ a hierarchical tessellation of the plane space into triangles where a constant function is used to estimate the elevation

    ◯ a piecewise tessellation of 3D space into tetrahedra where a linear function is used to estimate the elevation

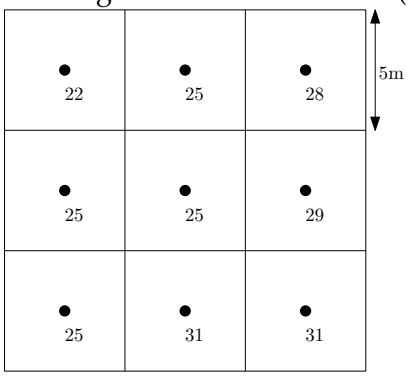
Short answer questions (60 points)

11. (6 points) We know the slope for a given location (x, y): its gradient (α) is 17° and its aspect (θ) is 215°. 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.

12. (6 points) Describe one concrete use of a kd-tree in the context of this course. If you don't use it for this task, what would be the main consequence(s)?

13. (6 points) You download one tile of CopernicusDEM-30 for the area around Delft and when you open it in QGIS you notice that size of the tile is 3600x2400 grid cells. Explain in details why that is.

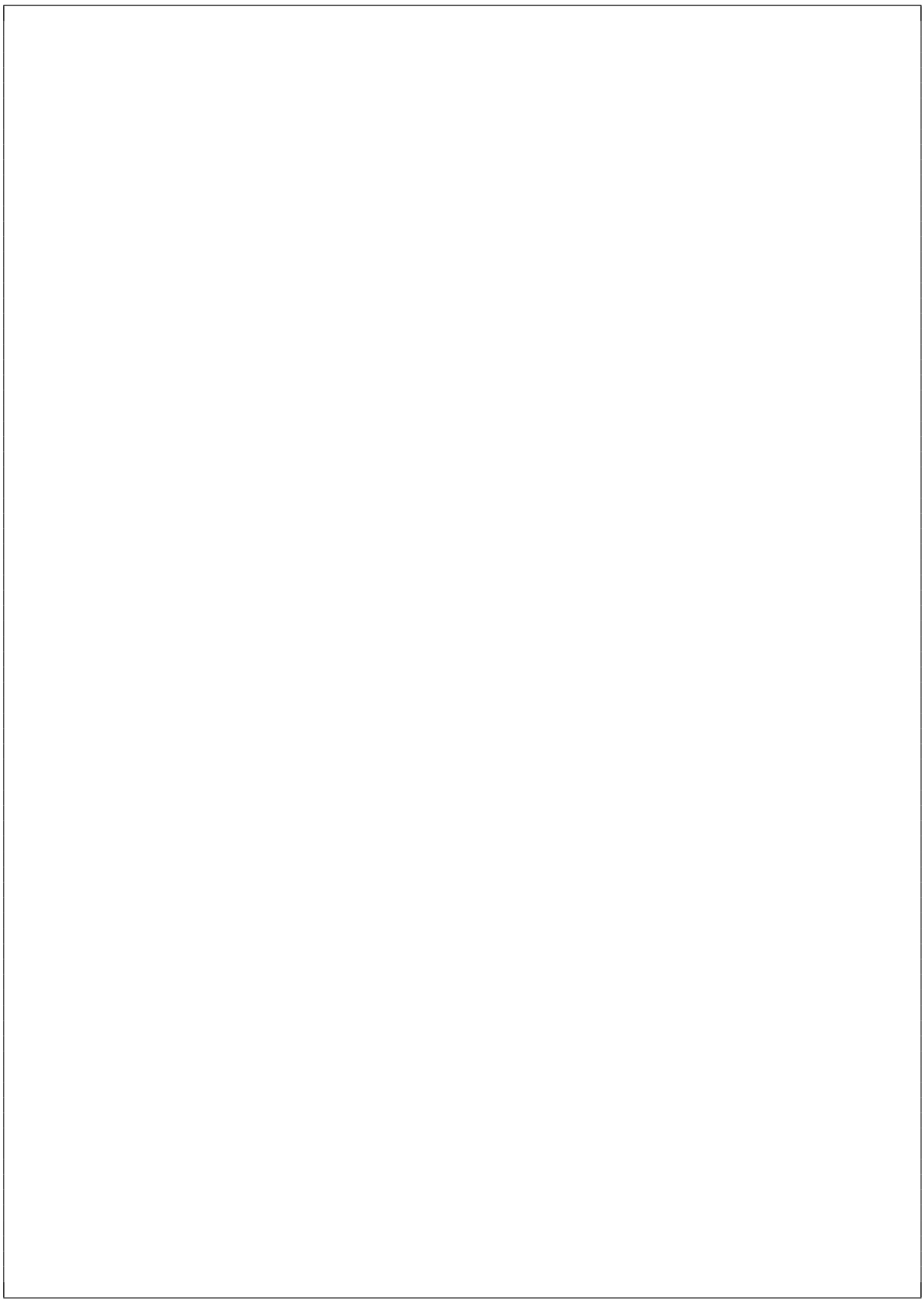
14. (6 points) Calculate both the gradient and the slope, using the finite difference method, for the grid cell in the middle. (Write down your development, not only the final answer)



15. (6 points) If you had to redo hw04 and use kriging instead of Laplace at Step 3 (to create the gridded DTM), what steps would you need to perform and what parameters would you have to determine. Be specific.

16. (6 points) Say you have access to the AHN4 point cloud of your house, explain how you would calculate the total area of your roof (can be several planes). This is to, for instance, calculate the number of solar panels that could be installed.

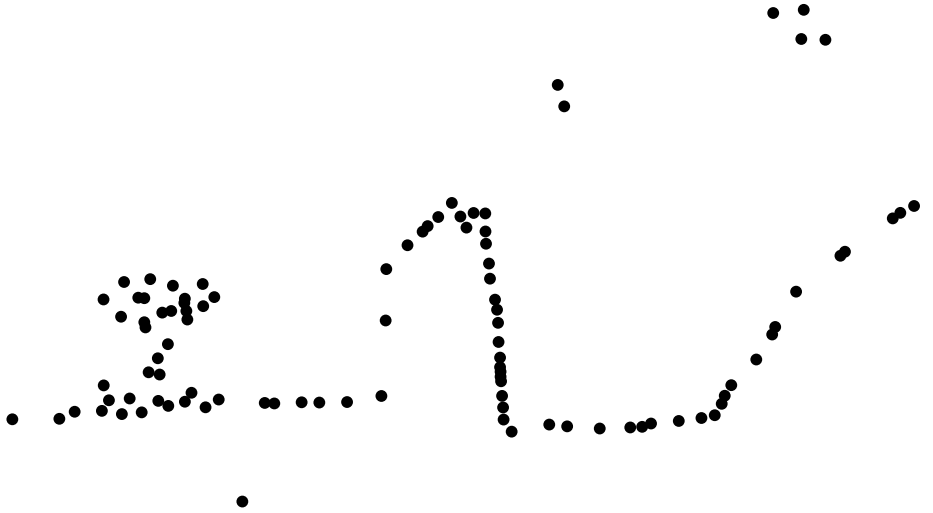
17. (6 points) You need to compute the convex hull of a 2-billion point dataset (in LAZ file). The memory of your computer doesn't allow you to use a library where all the points are loaded in memory (such as `startinpy`). Describe how you would tackle this problem by using ideas from the streaming triangulation framework, as explained in the course.



18. (6 points) You obtain the AHN4 point cloud of the area of BK-city area (including the parking) and you Delaunay triangulate it with `startinpy` (or any other library) and it reports that hundreds xy-duplicate points exist. Is this normal? Why is this happening?

19. (6 points) What is the use of NODATA values in DTMs? If a format does not support it, name 2 problems you might encounter? (Give concrete examples based on the 4 assignments you did)

20. (6 points) In the profile view of the point cloud below: (1) identify both the inliers and outliers; (2) explain in detail one algorithm that can be used to automatically remove the outliers. Use the figure to illustrate.



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