TU Delft Delft University of Technology

Faculty of the Built Environment & Architecture

**Digital terrain modelling (GEO1015) — 5 ECTS**

Location: 26.B0.030
Date & time: 3 February 2023, 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 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 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 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) 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.

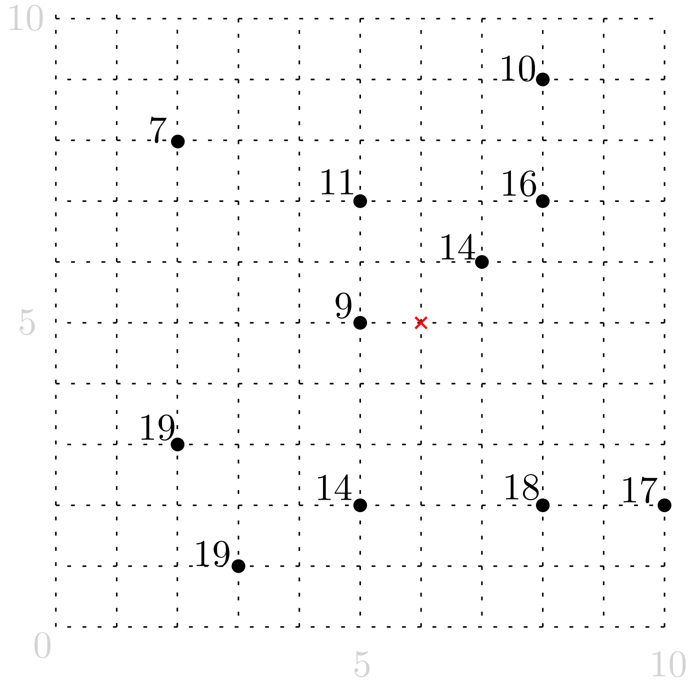
   ◯ true

   ◯ false

2. (2 points) If we estimate the elevation at location (6, 5) (the red cross) with: (1) IDW ($power$ = 2; $radius$ = 2.0) and (2) IDW ($power$ = 3; $radius$ = 2.0), do we get the same answer?

   ◯ yes

   ◯ no




3. (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

4. (2 points) Unlike the CSF algorithm, the TIN refinement ground filter algorithm is not affected by the presence of outliers in the datasets (because it can remove them with its 2 parameters).

   ◯ true

   ◯ false

5. (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

6. (2 points) Fill in the blank: When applying the bathymetric smoothing operator from Chapter 14, each iteration moves __________ the vertices of the TIN.
   - ◯ downwards, if at all
   - ◯ upwards, if at all
   - ◯ downwards or upwards, it depends on the configuration of the neighbours

7. (2 points) Where are you more likely to have many ICESat-2 measurements for a given area?
   - ◯ Kuala Lumpur (Malaysia)
   - ◯ Tromsø (Norway)

8. (2 points) You have a gridded DTM with 100 cells (10X10). If you assume that the value of each cell is at its centre and you create the DT of the 100 centre points, how many Delaunay triangles will you have?
   - ◯ 100
   - ◯ 121
   - ◯ 162
   - ◯ 200

9. (2 points) A *k*d-tree in 2D is a binary tree (every node has 2 children maximum), and in 3D it can have 3 children maximum.
   - ◯ true
   - ◯ false

10. (2 points) The main difference between applying runoff algorithms on a raster and a TIN is that:
    - ◯ single flow direction methods don't work on a TIN
    - ◯ drainage networks on a TIN will always have loops
    - ◯ the least-cost paths algorithm cannot be applied to a TIN
    - ◯ the area of each cell in a TIN (a triangle) is different

## Short answer questions (60 points)

11. (6 points) You can see below part of the starting code we gave for hw01 (`geo1015_hw01.py`). Why do we use a Delaunay triangulation when reading the points (line 43)? Also, describe in details one alternative we could have used to achieve the same.

```
25 def main():
26     #-- read the needed parameters from the file 'params.json' (must be in same folder)
27     try:
28         jparams = json.load(open('params.json'))
29     except:
30         print("ERROR: something is wrong with the params.json file.")
31         sys.exit()
32     #-- store the input 3D points in a DT
33     dt = startinpy.DT()
34     #-- cleaning of duplicates done in the process with tolerance of 1cm
35     dt.snap_tolerance = 0.01
36     with open(jparams['input-file']) as csvfile:
37         r = csv.reader(csvfile, delimiter=' ')
38         header = next(r)
39         totall = 0
40         for line in r:
41             p = list(map(float, line)) #-- convert each str to a float
42             assert(len(p) == 3)
43             dt.insert_one_pt(p[0], p[1], p[2])
44             totall += 1
45         if totall > dt.number_of_vertices():
46             print("INFO: {} duplicate points were removed".format(totall - dt.number_of_vertices()))
47     #-- fetch all the (clean) points (see https://startinpy.readthedocs.io/en/latest/api.html#startinpy.DT.points)
48     pts = dt.points[1:]
49     #-- construct a KD-tree also, for fast nearest neighbours queries
50     kd = scipy.spatial.KDTree(pts[:,:2])
51     all_z = pts[:,-1]
52     #-- find bbox, we get bbox[minx,miny,maxx,maxy]
53     bbox = dt.get_bbox()
```

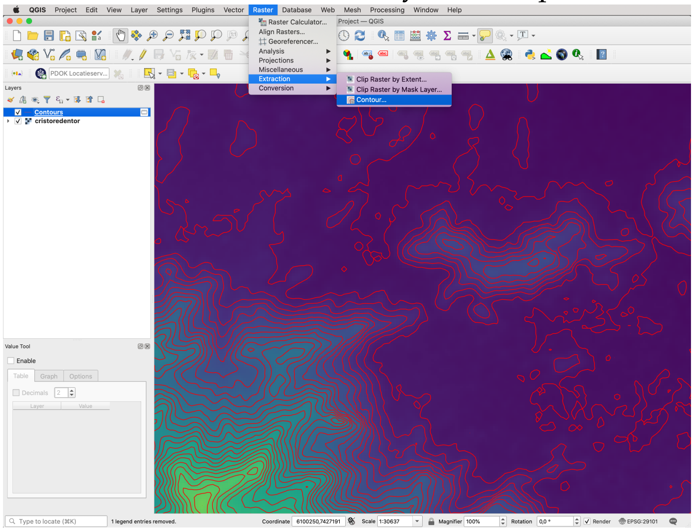
12. (6 points) Based on your experience with hw03, which kriging method is able to achieve a better result? How were you able to determine this?

13. (6 points) Say you want to construct a gridded 0.5mX0.5m DSM of 4 tiles of the AHN3 (so around 2B points) and you are asked to do so with the streaming paradigm. Describe how you could modify or add operators to the pipeline described in the book so that a gridded DSM is constructed.

14. (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)

15. (6 points) For calculating the line-of-sight query of a point $v$ to another $q$, it is mentioned that the calculations are simpler when we have a 2.5D terrain. Explain in details what that means, and give a concrete example (draw the profile of a case) where it would clearly be faster.

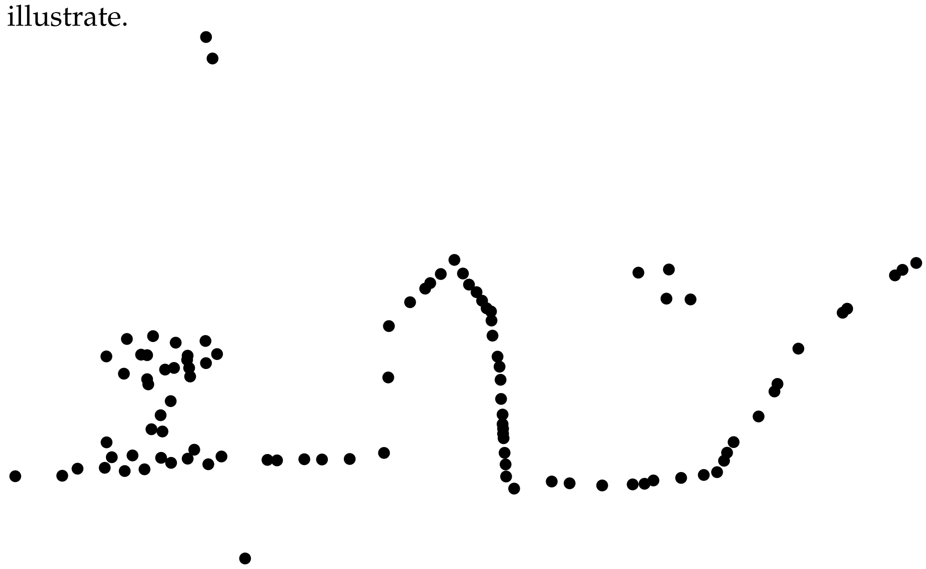
16. (6 points) You are asked to create isolines of the gridded AHN3 file below. You use QGIS/GDAL functions to extract the isolines at every 2m and you obtain those lines: not very smooth and several unconnected components. Describe a methodology that you could apply to the data to improve the output 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.



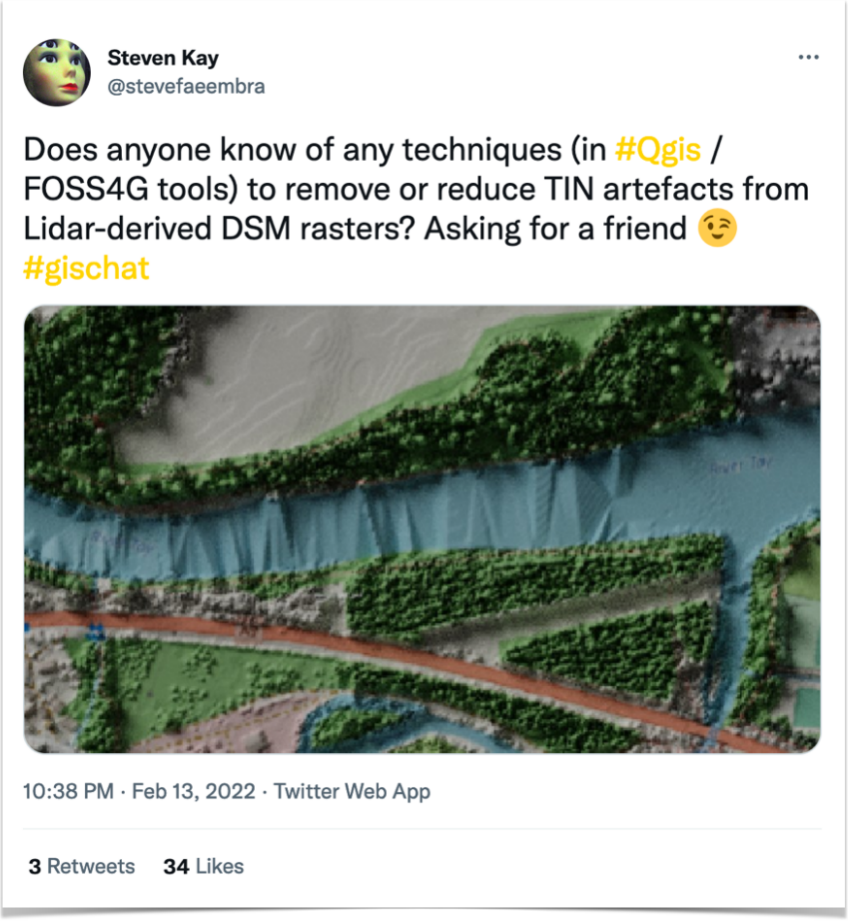
17. (6 points) In the book in Section 5.1, there is a list of 7 properties that an ideal interpolation method should have: exactness, continuity, smoothness, locality, adaptability, computational efficiency, and automation. Explain, in a few words, how well kriging fulfils each of them (or not) and why.

18. (6 points) You are asked to identify all roofs segments in Delft that would potentially be suitable to install solar panels. This is defined as an area larger than $4m^2$ and facing South (that is the aspect of the roof segment must be between 110 and 250 degrees). If you have access to the (classified) AHN3 point cloud in LAZ format, describe how you would proceed to answer that question (you can use code, QGIS, CloudCompare, etc.).

19. (6 points) In the profile view of the point cloud below: (1) circle the outliers; (2) explain in detail one algorithm that can be used to automatically remove these. Use the figure to illustrate.



20. (6 points) We saw this question on Twitter a while ago. Based on what you have learned in this course, give an answer (more than 280 characters is allowed!).



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