MSc thesis in Geomatics

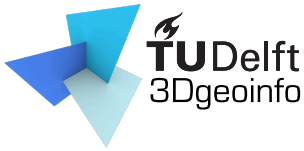
The optimal Delaunay triangulation of cheesy songs

Céline Dion

November 2024

A thesis submitted to the Delft University of Technology in partial fulfillment of the requirements for the degree of Master of Science in Geomatics

The work in this thesis was carried out in the:



3D geoinformation group
Delft University of Technology

Supervisors: Prof.dr. Jan Smit
Dr. Gerard Joling

Co-reader: ir. Gordon Heuckeroth

Abstract

> **Info**
>
> Should fit on one page.

Lemongrass frosted gingerbread bites banana bread orange crumbled lentils sweet potato black bean burrito green pepper springtime strawberry ginger lemongrass agave green tea smoky maple tempeh glaze enchiladas couscous. Cranberry spritzer Malaysian cinnamon pineapple salsa apples spring cherry bomb bananas blueberry pops scotch bonnet pepper spiced pumpkin chili lime eating together kale blood orange smash arugula salad. Bento box roasted peanuts pasta Sicilian pistachio pesto lavender lemonade elderberry Southern Italian citrusy mint lime taco salsa lentils walnut pesto tart quinoa flatbread sweet potato grenadillo.

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Acknowledgements

Thanks to everyone, especially my supervisors and my dog (in that order). Obviously, thanks also to the brilliant minds who created this *fantastic* template!

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Thai super chili apricot salad cocoa dark chocolate vitamin glow mushroom risotto red amazon pepper simmer udon noodles soba noodles dragon fruit cherries strawberry mango smoothie basil chickpea crust pizza cauliflower cherry bomb pepper mediterranean street style Thai basil tacos. Balsamic vinaigrette Indian spiced kimchi tofu sandwiches smoked tofu apple vinaigrette salty Thai sun pepper cayenne four-layer fiery fruit peach strawberry mango vegan Bulgarian carrot Italian linguine puttanesca green bowl lemon red lentil soup overflowing berries habanero golden one bowl.

Contents

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TODOs

1. Introduction

This is a complete template for the MSc Geomatics thesis. It contains all the parts that are required and is structured in such a way that most/all supervisors expect. Observe that the MSc Geomatics at TU Delft has no formal requirements, how the document looks like (fonts, margins, headers, etc) is entirely up to you.

We basically took the template LaTeX at https://github.com/tudelft3d/msc_geomatics_thesis_template and tried to convert it to Typst.

> **Info**
>
> It is not an official template and it is not mandatory to use it.

But we hope it will encourage everyone to use Typst for writing their thesis, and we also hope that it will *discourage* some from using Word.

If you run into mistakes/problems/issues, please report them on the GitHub page, and if you fix an error, then please submit a pull request.

1.1. Cross-references

Chapter 1 is to refer to the Chapter, but all other sections you can just use Section 1.2 or Section 1.1.

For a figure, you can also just use Figure 1.2, but I guess you can qualify it with whatever you fancy, eg Hugo 1.2.

1.2. Figures

> **Info**
>
> At the moment (v0.14 of Typst), Typst supports natively figures in PDF, PNG, SVG, JPG, and GIF (with `#image()`).

Figure 1.1 is a simple figure in PNG format, notice the use of `placement: auto` to put the figure at the best place possible (top or bottom, Typst decides for you).

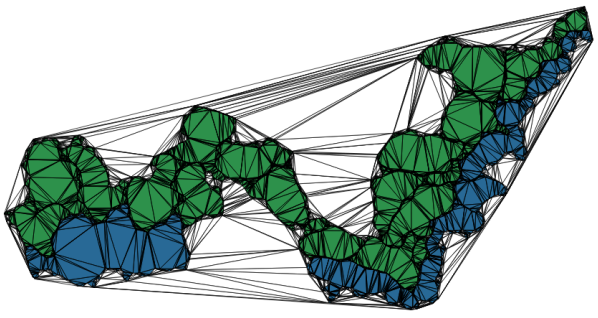
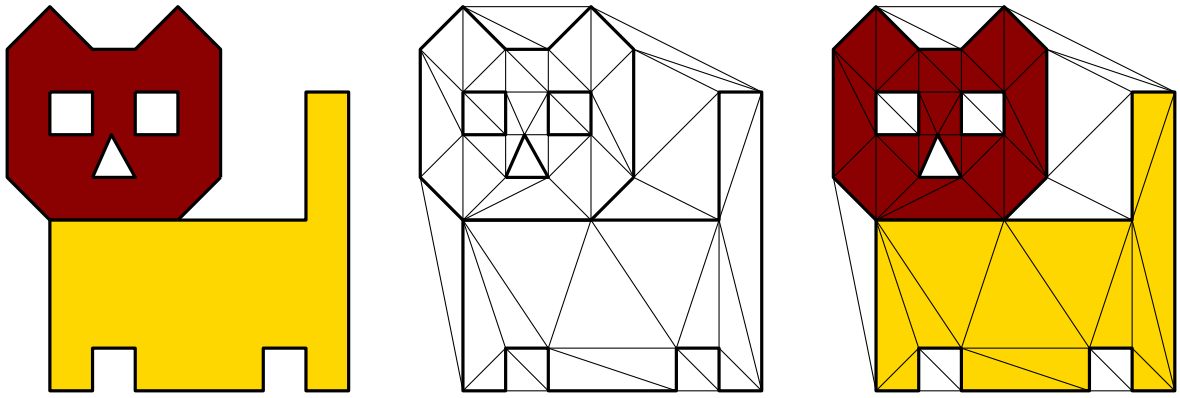


Figure 1.1: Two nice figure.



(a) (b) (c)

Figure 1.2: Three figures side-by-side. **(a)** A cat formed of 2 polygons. **(b)** its triangulation. **(c)** with some colours. Notice that the figure is one PDF file with 3 pages, the page to display can be chosen.

> **Info**
>
> All figures in your thesis should be referenced to in the main text. The same applies to tables and algorithms.

As shown in Figure 1.2, it is possible to have two figures (or more) side by side. You can also refer to a *subfigure*: see Figure 1.2b.

1.3. References

We know from Descartes (1637) that this can be done, and others have done that too (Descartes, 1637).

And Van Kreveld (1996) did write nice papers, and others too (Campen et al., 2012).

1. (Voronoi, 1908)
2. (Voronoi, 1908)
3. (Voronoi, 1908)
4. (Voronoi, 1908)

To cite several papers for one sentence, just chain commands together (Aurenhammer et al., 2012; Delaunay, 1934). And Delaunay (1934, p. 77) to specify a specific page, and 2012 just to add the year.

When adding references to your BibTeX file, it is good pratice to add the DOI of the paper. For example, for a paper:

```
@book{Aurenhammer12,
  author = {Aurenhammer, Franz and Klein, Rolf and Lee, Der-Tsai},
  doi = {10.1142/8685},
  publisher = {World Scientific},
  title = {Voronoi diagrams and {D}elaunay triangulations},
  year = {2012}
}
```

Notice that if you use the field `doi` you shouldn't append `http://doi.org/` (the full DOI being http://doi.org/10.1142/8685). If you do this then you'll have clickable DOIs in your list of references.

	solids	faces	vertices	constraints
campus	370	4 298	5 970	3 976
kvz	637	6 549	8 951	13 571
engelen	1 629	15 870	23 732	15 868

Table 1: Details concerning the datasets used for the experiments.

1.4. Footnotes

Footnotes are a good way to write text that is not essential for the understanding of the text[1].

1.5. Equations

Equations and variables can be put inline in the text, but also numbered.

Let S be a set of points in $\mathbb{R}^d$. The Voronoi cell of a point $p \in S$, defined $\mathcal{V}_p$, is the set of points $x \in \mathbb{R}^d$ that are closer to p than to any other point in S; that is:

$$\mathcal{V}_p = \{x \in \mathbb{R}^d \mid |x - p| \leq |x - q|, \forall q \in S\}. \tag{1.1}$$

The union of the Voronoi cells of all generating points $p \in S$ form the Voronoi diagram of S, defined VD(S).

1.6. Tables

Tables builtin in Typst are pretty powerful, see https://typst.app/docs/guides/table-guide/. If you need some of the features of LaTeX `booktabs`, it seems that tablex is your friend: https://typst.app/universe/package/tablex.

An example of a simple table is in Table 1.

❤️ You can even read directly from a CSV file this way:

TimeCEST	TemperatureC	Humidity
12:00 AM	10	67
12:25 AM	9.0	82
12:55 AM	10.0	76
1:00 AM	10	74
1:25 AM	10.0	76
1:55 AM	10.0	76
2:00 AM	9	78
2:25 AM	9.0	82
2:55 AM	9.0	87
3:00 AM	9	81
3:25 AM	10.0	82
3:55 AM	10.0	82
4:00 AM	10	74
4:25 AM	9.0	82

[1] but please do not overuse them

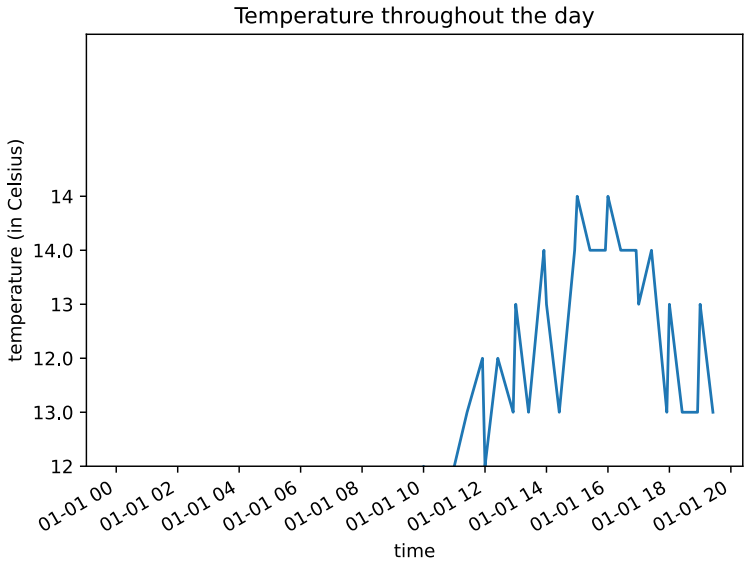


Figure 1.3: A super plot.

1.7. Plots

The best way is to use matplotlib, or its more beautiful version seaborn. With these, you can use Python to generate nice plots, such as that in Figure 1.3.

In the folder `./plots/`, there is an example of a CSV file of the temperature of Delft, taken somewhere. From this CSV, the plot is generated with the script `createplot.py`.

1.8. Pseudo-code

Please avoid putting code (Python, C++, Fortran) in your thesis. Small excerpt are probably fine (for some cases), but do not put all the code in an appendix. Instead, put your code somewhere online (eg GitHub) and put *pseudo-code* in your thesis. The package `lovelace` is pretty handy, see for instance Algorithm 1. All your algorithms will be automatically added to the list of algorithms at the begining of the thesis.

Input: A Delaunay tetrahedralization $\mathcal{T}$, a starting tetrahedron τ, and a query point p
Output: τ_r: the tetrahedron in $\mathcal{T}$ containing p
while τ_r not found
  for $i \leftarrow 0$ **to** 3 **do**
    $\sigma_i \leftarrow$ get opposite vertex i in τ
    if Orient $(\sigma_i, p) < 0$ **then**
      $\tau \leftarrow$ get neighbouring tetrahedron of τ incident to σ_i
      break
  if $i == 3$ **then**
    //– all the faces of τ have been tested
    return $\tau_r = \tau$

Algorithm 1: Walk $(\mathcal{T}, \tau, p)$

```
<gml:Solid>
  <gml:exterior>
    <gml:CompositeSurface>
      <gml:surfaceMember>
        <gml:Polygon>
          <gml:exterior>
            <gml:LinearRing>
              <gml:pos>0.000000 0.000000 1.000000</gml:pos>
              <gml:pos>1.000000 0.000000 1.000000</gml:pos>
              <gml:pos>1.000000 1.000000 1.000000</gml:pos>
              <gml:pos>0.000000 1.000000 1.000000</gml:pos>
              <gml:pos>0.000000 0.000000 1.000000</gml:pos>
            </gml:LinearRing>
          </gml:exterior>
          <gml:interior>
          ...
      </gml:surfaceMember>
    </gml:CompositeSurface>
  </gml:interior>
</gml:Solid>
```

Listing 1: Some GML for a `gml:Solid`.

1.9. Source/raw code

You can use exactly the same principle as in Markdown, and you can wrap the raw code in a `#figure` to have a caption and place it where you want (see Listing 1).

1.10. And finally what matters the most: emojis!

😄🚀🍝

1.11. TODOs

At A3 or for earlier drafts, it might be good to let the readers know that some part need more work. Or that a figure will be added.

The package https://typst.app/universe/package/dashy-todo/ is perfect for this.

make sure that the URL is correct :J

TODOs can be any colours

A summary of all TODOs in the thesis can even be generated with an `#outline` command, see page xiii and the file `main.typ`.

2. Related Work

In Chapter 1 we saw many important things. And in Section 1.1 we saw some too.

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2.1. Some new section

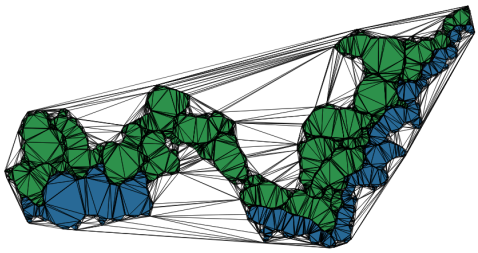

Figure 2.1: A triangulation

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2.2. Some new section again

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1. **What:** Specify which AI/LLM tool(s) you used (eg ChatGPT, Claude, Copilot, etc.).
2. **How:** Briefly describe how you used these tools (eg generating outlines, writing, coding, data analysis, editing, etc.).
3. **Extent:** Indicate the extent of their use (eg occasional assistance, regular drafting, checking grammar, etc.).
4. **Ethics:** Confirm adherence to academic integrity and that AI/LLM did not generate falsified, fictional, or plagiarized content.

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To promote open science and research integrity, please include a statement about the reproducibility of your MSc thesis work.

Address the following points concisely:

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2. **Code Availability:** Is your code and analysis workflow openly available? This can be for instance via GitHub, OSF, Zenodo. Include the relevant link or DOI if applicable. It is suggested to follow those guidelines for reproducibility: https://geomatics.bk.tudelft.nl/geogeeks/git/goodgit/.
3. **Documentation:** Have you provided clear instructions, README files, or notebooks so others can understand and reproduce your results?
4. **Reproducibility Rating:** Self-rate your overall reproducibility using the following scale:
    - **High:** All data and code fully available, well-documented, and tested to reproduce main results.
    - **Moderate:** Most data and code available, basic documentation, some steps may require clarification.
    - **Low:** Limited or no data/code sharing, minimal documentation, reproduction unlikely.

B.1 Example statement

"All data and analysis code related to this thesis are openly accessible at `[insert link]`. Complete instructions and a sample workflow are provided in the project README. I rate the reproducibility of this thesis as **high** according to the provided scale."

B.2 Examples of good MSc Geomatics repositories

1. https://github.com/chenzhaiyu/points2poly
2. https://github.com/ellieroy/no-floors-inference-NL
3. https://github.com/NoortjevanderHorst/treegrowthmodelling
4. https://github.com/fabisser/stylesdf

C Some UML diagrams

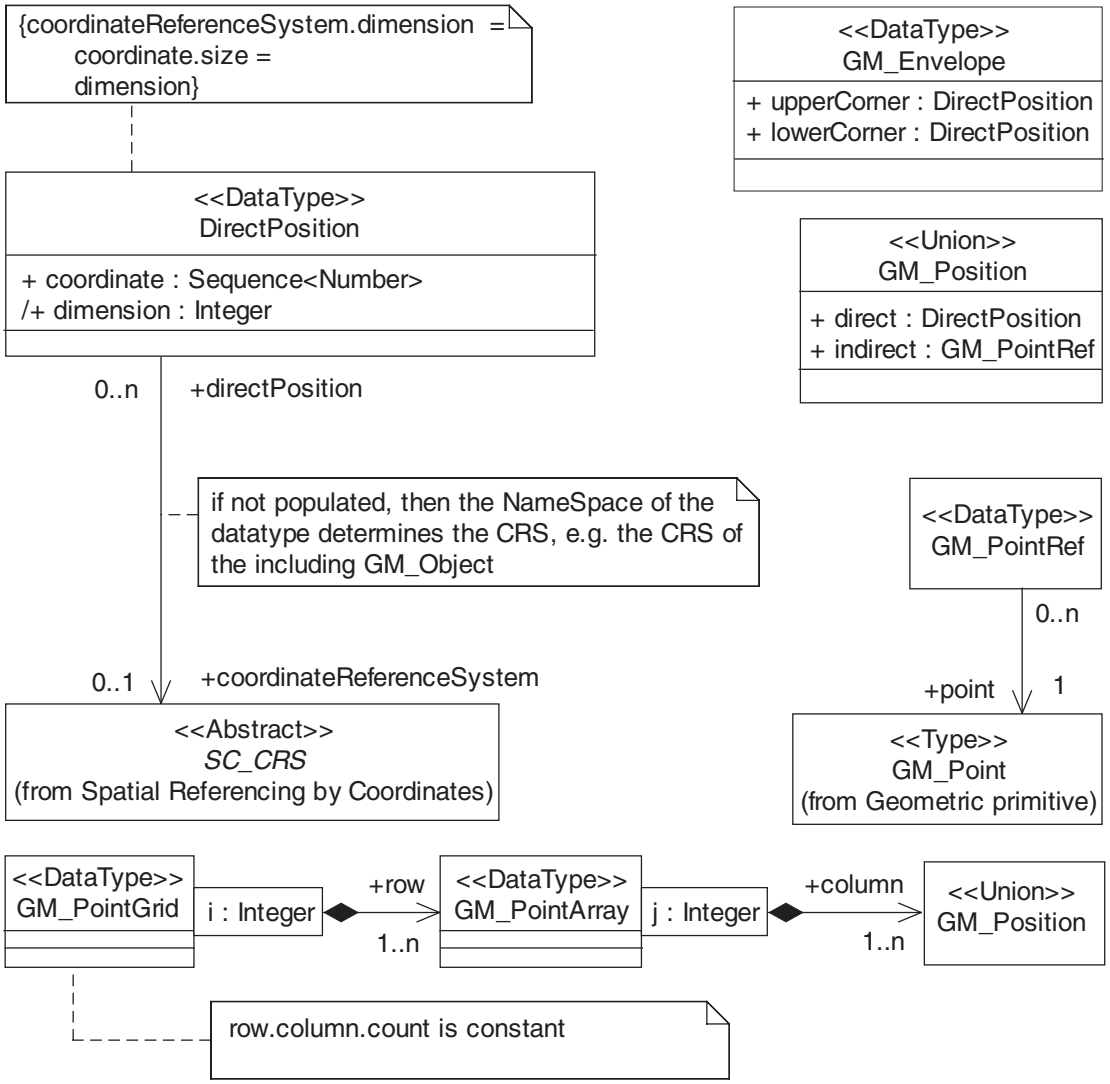

Figure C.1: The UML diagram of something that looks important.

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