P3

1.2.2 Strategy #1: points + global interpolation function.

This means storing the original sample points with the parameters of the *global* spatial interpolation method that is best suited to the distribution of the samples and their accuracy. Global methods are for instance inverse-distance to a power, natural neighbours, or Kriging. This strategy is used because one can compactly represent a field (only the samples and a few parameters need to be stored).

Notice that this strategy permits us to reconstruct the continuity of a terrain from the samples by calculating the value of the elevation, but that this value is *not* persistently stored in memory. It is therefore less used in practice than the next strategy, which allows us to permanently store the terrain in a file and avoids us recomputing every time al the needed elevation values.

all ?

P4

1.3.2 Regular Tessellations

As shown in Figure 1.3a, all the cells have the same shape and size. The most common regular tessellation in GIS and in terrain modelling is by far the grid (or raster representation), in which the cells are squares in 2D (usually called *pixels*, a portmanteau of 'picture' and 'element', as an analogy to digital images). However, while they are not common in practice, other regular shapes are possible, such as hexagons or triangles.

Observe that a regular tessellation often arbitrarily tessellates the space covered by the field without taking into consideration the objects embedded in it (the samples). This is in contrast with irregular tessellations in which, most of the time, the shape of the cells constructed depends on the samples.

In practice this means that, if we have a terrain stored as a regular tessellation we can assume that it was constructed from a set of samples by using spatial interpolation. Converting sample points to cells is not optimal because the original samples, which could be meaningful points such as the summits, valleys or ridges of a terrain, are not necessarily present in the resulting tessellation. There is there a loss of information, since the exact location of the meaningful points are lost.

therefore?

P5

1.3.3 Irregular Tessellations

The cells of an irregular tessellation can be of any shape and size, and they usually 'follow'—or are constrained by—the samples points that were collected, albeit this is not a requirement. Subdividing the space based on the samples has the main advantage of producing a tessellation that is *adaptive* to the distribution of the samples. The subdivision is potentially better than that obtained with regular tessellations (which subdivide arbitrarily the space without any considerations for the samples).

The most known examples of the use of irregular tessellations in terrain modelling is the *triangulated irregular network*, or TIN. As shown in Figure 1.4, a TIN refers to an irregular tessellation of the xy-plane into non-overlapping triangles (whose vertices are formed by three sample points), and to the use of a linear interpolation function for each triangle. One way to explain the 2.5D properties of a TIN is as follows: if we project vertically to the xy-plane the triangles in 3D space forming the TIN, then no two triangles will intersect.

While not a requirement, the triangulation is usually a Delaunay triangulation (more about this in Chapter 3). The main reason is that Delaunay triangles are as "fat" as possible (long and skinny triangles are avoided), and thus they are behave better for interpolation. As can be seen in Figure 1.5, the estimated

they behave?

P12

2.1.2 Photogrammetry

repeated setences

Photogrammetry allows us to measure the distance from overlapping photographs taken from different positions. If a ground point, called a *feature*, is identifiable in two or more images, its 3D coordinates can be computed in two steps. First, a viewing ray for that feature must be reconstructed for each image. Photogrammetry allows us to measure distance from overlapping photographs taken from different positions. First, a viewing ray for that feature must be reconstructed for each image. A viewing ray can be defined as the line from the feature, passing through the projective centre of the camera, to the corresponding pixel in the image sensor (see Figure 2.1b). Second, considering that we know the orientation and position of the camera, the distance to the feature (and its coordinates) can be computed by calculating the spatial intersection of several viewing rays.

losing space? i.e. the

The number of 3D point measurements resulting from photogrammetry thus depends on the number of features that are visible in multiple images, iethe so-called *matches*. With *dense image matching* it is attempted to find a match for every pixel in an image. If the *ground sampling distance*, ie the pixel size on ground level, is small (around 5cm for state-of-the-art systems), point densities of hundreds of points per square meter can be achieved, which is much higher than the typical lidar point cloud (typically up to dozens of points per square meter).

P13

captures

Because photography is used, photogrammetry gives us also the colour of a the target surface, in addition to the elevation. This could be considered an advantage over lidar which capture several attributes for each point (eg the intensity of measured laser pulse and the exact GPS time of measurement), but colour is not among them.

Both airborne and spaceborne photogrammetry are possible.

P13

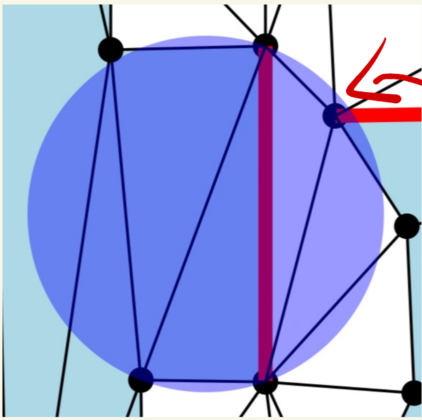
2.2 Artefacts

and

There are many aspects, both in our control as not in our control, in the acquisition process that affect the quality and usability of the resulting elevation data for a given application. Some examples are

P32

Figure 3.17: The ConsDT of a set of segments. On the right, the triangle whose circumcircle is green is a Delaunay (no other points in its interior) and so is the triangle whose circumcircle is in blue (there is one point in its interior, but it cannot be seen because of the constrained segment).



it's purple not blue.

P36

for datasets where the data density varies greatly from one location to another.

6. **computationally efficient**: it should be possible to implement the method and get an efficient result. Efficient is of course subjective. For a student doing this course, efficiency might mean that the method generates a result in matter of minutes or an hour on a laptop, for the homework dataset. For a mapping agency, running a process for a day on a supercomputer for a whole country might be efficient. Observe that the complexity of the algorithm is measured not only

Efficiency

uses the 4 centres to perform the interpolation at location $p = (p_x, p_y)$; it is thus a weighted-average method because the 4 samples are used, and their weight is based on the linear interpolation, as explained below. We need to linearly interpolation the values at locations q and r with linear interpolation, and then linearly interpolate along the y axis with these values. Also, cotice that the result is independent of the order of interpolation: we could start with interpolating along the y axis and then the x axis

P43

Notice

P54

$E[\hat{Z}_0]$

$$
\begin{aligned}
\underline{E\left[Z_0\right]} &= E\left[E[Z_0] + \sum_{i=1}^{n} w_i R_i\right] \\
&= E[Z_0] + \sum_{i=1}^{n} w_i \cancel{E[R_i]}^{\,0} \\
&= E[Z_0].
\end{aligned}
$$

P65

Saddle point. As shown in Figure 6.6b, a saddle point, also called a pass, is a point whose neighbourhood is composed of higher elevations on two opposite directions, and 2 lower elevations in the other two directions. From a mathematic point-of-view, it is a point for which the derivates in orthogonal directions are 0, but the point is not maximum (peak) or a mininum (pit).

If we consider the contour line of a saddle point p, then there are 4 or more contour line segments

derivatives