

Danyel Merkert

CoVis 3

Visual Representaion of three-dimensional Data and
Functions of two Variables

Bachelor Thesis

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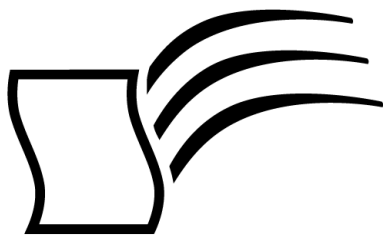
Visual Representaion of three-dimensional Data and Functions of two Variables

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Functions of two Variables*

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Diplomica GmbH _____
Hermannstal 119k _____
22119 Hamburg _____

Fon: 040 / 655 99 20 _____
Fax: 040 / 655 99 222 _____

agentur@diplom.de _____
www.diplom.de _____

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Abstract

The visualisation of information is a broad area of study not uniquely associated with computing. Its origins can be traced back to the earliest attempts at cartography. It is, however, with the development of computing technology that the discipline has flourished. It is not simply that the technology has allowed for more detailed visual representations to be produced, it is equally the case that the wealth of data available and the understanding of its importance have accelerated the demand for its analysis. The range of modern visualisation is huge, including medical imaging, engineering simulations and geographical and meteorological analysis.

Information can come in many forms – the two most common to visualisation are numerical data and functional representation. This thesis investigates visualisation methods for both mathematical functions of two variables and three-dimensional data. In particular I examined techniques as contour plots and surface plots.

Within the bounds of this project *OpenGL* turned out to be the most powerful tool regarding visualisation of information. Due to the procedural architecture of *OpenGL* and an ambition to learn the core architecture of *Microsoft Windows*®, I decided to exclusively implement this project in *Win32*®, for which I pay particular attention in this dissertation.

Table of Contents

1	Introduction	5
1.1	Visualisation.....	5
1.2	History	8
1.3	Literature Review	9
1.4	Summary of Dissertation.....	10
2	The Application	12
2.1	Overall	12
2.2	Components.....	15
2.2.1	Toolbar	16
2.2.2	Information Window	16
2.2.3	Manipulation Modes	16
2.2.4	Contour Map	18
2.2.5	Acquiring data files	19
2.2.6	Creating datasets of mathematical formulas	21
2.2.7	Colour Shading.....	23
2.3	User Profile	24
2.4	Alternatives for CoVis3	25
3	Technical Foundations.....	28
3.1	Win32 API.....	28
3.1.1	Why I chose the Win32 API	28
3.1.2	Creating a window	29
3.1.3	Event Handling.....	31
3.1.4	Keyboard Handling	32
3.1.5	Mouse Handling	34
3.1.6	Resources	36
3.1.7	Buttons	36
3.1.8	Edit Controls	36
3.1.9	List Boxes.....	37
3.1.10	Trackbars.....	38

3.1.11	Menus	39
3.2	OpenGL	41
3.2.1	The OpenGL architecture	41
3.2.2	Creating an OpenGL window	42
3.2.3	Adapting the OpenGL Scene.....	44
3.2.4	Objects.....	45
3.2.5	Colours	46
3.2.6	Fonts in Open GL	47
4	Data Representation.....	49
4.1	Equally spaced data points	50
4.1.1	Meshes.....	50
4.1.2	Isometric surfaces.....	53
4.1.3	Contour plots	56
4.1.4	File format	60
4.2	Unequally spaced data points	62
4.2.1	Delaunay Triangulation.....	62
4.2.2	Contour Plots.....	71
4.2.3	File format	72
5	Conclusion & Future Work.....	76
	Bibliography	78

Table of Figures

Figure 1.1	Representation of mathematical functions on XY-plane	5
Figure 1.2:	Curve of mathematical function $f(x)=x^2$	6
Figure 1.3:	Visualisation of a mathematical function of two variables $f(x,y)=x^2+y^2$	6
Figure 1.4:	Typical contour plot	7
Figure 1.5:	Population of Sweden between 1750 and 1875	8
Figure 2.1:	CoVis3 visualising a mathematical formula	12
Figure 2.2:	Window structure of CoVis3.....	13
Figure 2.3:	Dependencies in CoVis3.....	14
Figure 2.4:	Main Window of CoVis3.....	15
Figure 2.5:	Different mouse cursors of CoVis3	17
Figure 2.6:	Rotation mode	18
Figure 2.7:	Contour map of ice-thickness dataset at the value of 1846.6m.....	18
Figure 2.8:	Dialog for changing the contour value	19
Figure 2.9:	Loading a dataset.....	19
Figure 2.10:	After the user has selected an unequally spaced dataset, the application connects the data points	20
Figure 2.11:	Dialog for creating a dataset of a mathematical function.....	21
Figure 2.12:	CoVis3 performing the mathematical formula $f(x,y)=x^2 \cdot y^2$	22
Figure 2.13:	Adjusting colour shading	23
Figure 2.14:	Main screen of Maple 5, visualising a mathematical equation of two unknowns.....	25
Figure 2.15:	Matlab performing a composite mathematical formula	26
Figure 2.16:	3D surface chart of Microsoft Excel	27
Figure 3.1:	Dependencies for Win32.....	28
Figure 3.2:	A typical Trackbar.....	38
Figure 3.3:	The OpenGL rendering pipeline	41
Figure 3.4:	OpenGL hierarchy on Windows systems.....	42
Figure 3.5:	Triangle with smooth colour shading.....	46
Figure 4.1:	Equally spaced data points	49
Figure 4.2:	Unequally spaced data points.....	49
Figure 4.3:	Mesh plot of $f(x,y) = \sin(x + \sin(y))$ as isometric view.....	56

Figure 4.4:	Four equally spaced data points	57
Figure 4.5:	Values referring to contour value	57
Figure 4.6:	Simplest possibility of contour within the marching square	58
Figure 4.7:	16 marching squares	58
Figure 4.8:	Contour plot of $f(x, y) = x^2 + y^2$	60
Figure 4.9:	File format for equally spaced datasets: .esd	61
Figure 4.10:	Possible connections of four data points	63
Figure 4.11:	Two triangles, not fulfilling the circumcircle criterion	63
Figure 4.12:	Two triangles, fulfilling the circumcircle criterion	64
Figure 4.13:	Ambiguous case in Delaunay Triangulation	64
Figure 4.14:	Intersection of perpendicular bisectors	65
Figure 4.15:	New sample point to be added to existing triangular mesh	68
Figure 4.16:	Triangles whose circumcircle encloses the new sample point	68
Figure 4.17:	Triangular mesh after removing doubly specified edges	69
Figure 4.18:	New triangles formed from new point to the outside edges of the enclosing polygon	69
Figure 4.19:	The supertriangle is encloses every sample point	69
Figure 4.20:	8 possible marching triangles	71
Figure 4.21:	File format for unequally spaced datasets: .usd	72

1 Introduction

Numerical data, in its raw form, is extremely difficult to assimilate. The larger and more complicated the datasets, the more unlikely it is that a reader will be able to ascertain the most implicit characteristics of the information from the basic data. An effective graphical representation should clearly display the critical features of the data.

1.1 Visualisation

Visualisation of data starts with a facility to visualise mathematical functions. Mathematical functions of two variables $f(x,y)$ can describe three dimensional surfaces, where each value of x and y defines a certain function value. These values can then be transferred to the z -axis $z=f(x,y)$. Figure 1.1 shows a surface generated by the mathematical function $f(x,y)=0$. As this formula describes that every point on the XY -plane equals 0, the resulting surface has no elevations.

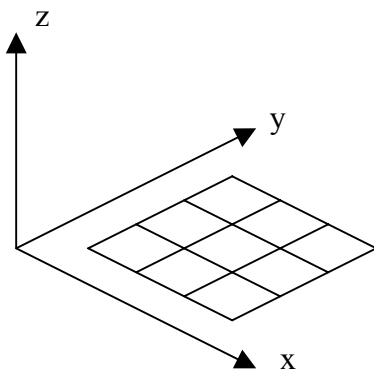


Figure 1.1 Representation of mathematical functions on XY -plane

In order to understand mathematical formulas with two variables, we have to consider these formulas from a very basic point of view. Mathematical functions with one variable $f(x)$ describe curves. This occurs because each value of x defines a certain value in y direction $y = f(x)$. Figure 1.2 shows the curve of the formula for $f(x)=x^2$.

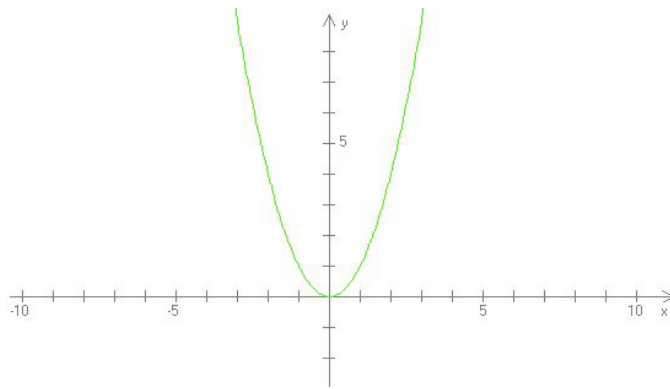


Figure 1.2: Curve of mathematical function $f(x)=x^2$

As already discussed, the definition of surfaces needs formulas of two variables. In three dimensions, it is possible to define a formula depending on x (which is meant by $f(x)$) to either the y axis or the z axis of the coordinate system. If we apply the formula $f(x)=x^2$ to the z axis, and also the formula $f(y)=y^2$ to the z axis, these two formulas describe an outline for a surface.

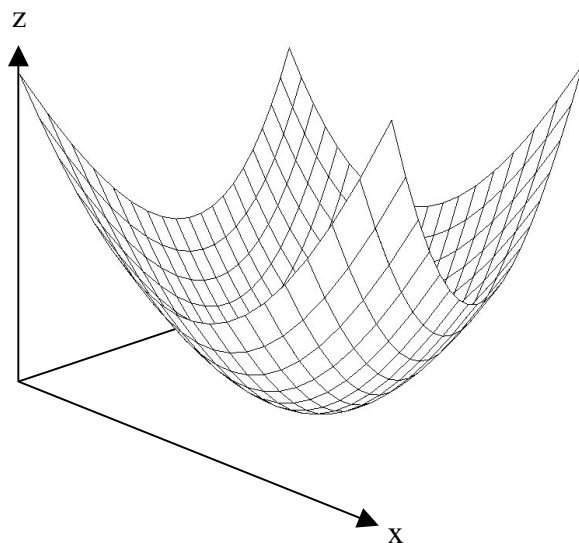


Figure 1.3: Visualisation of a mathematical function of two variables $f(x,y)=x^2+y^2$

However, the difficult part is to find how to combine these formulas. A simple way of achieving this is to add both values for x and y . This results in the formula $f(x,y)=x^2+y^2$. Figure 1.3 illustrates this mathematical function of two variables.

In engineering it is a broadly common to describe surfaces with mathematical functions. For example car manufacturing needs methods to describe aerodynamic surfaces for bonnets or wings. In these situations mathematical functions are better suited than data points connected

by lines because surfaces described by mathematical functions provide an infinite accuracy. One problem with functions however is that they can only be represented by a series of data points calculated from the function. A mathematical function can only be approximated by a dataset, containing a finite number of sample points.

Nevertheless, data can also be obtained by direct measuring of physical objects. Nowadays there are many areas where huge quantities of measured data have to be visualised (e.g. in scientific and medical areas). In medical areas it is vital to facilitate the view of parts of the human body or even the entire human body. There are also methods to obtain data from the surface of an object. One such technique is laser scanning. This technique simply measures the distance from the object's surface to the laser. The laser then continues scanning and recording data from every spot of the object. This method is not only applicable in medical areas; it can be used for almost every object. Often there is a need for displaying objects that are obscured from direct view. One example for this is the visualisation of objects hidden by the human body like the heart or the liver. This is already possible through the discovery of X-Rays. Another methods involve the collection of data by ultrasonic.

However, there are also very powerful techniques for visualising three-dimensional data as two-dimensional representations. For maps it is necessary to have a technique to visualise data of the third dimension – the height. Therefore contour lines provide a very good representation of heights. A contour line joins points of equal elevation so that everything within the boundaries of one contour line is at approximately the same elevation.

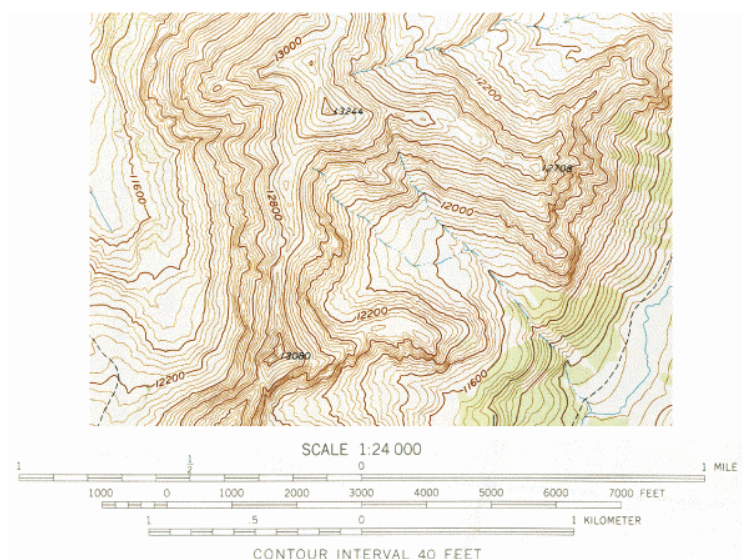


Figure 1.4: Typical contour plot