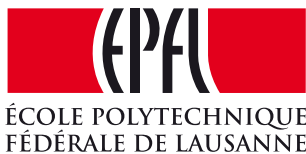


FIRST LINE OF TITLE

SECOND LINE OF TITLE

THIS IS A TEMPORARY TITLE PAGE
It will be replaced for the final print by a version
provided by the service academique.



Thèse n. 1234 2011
présenté le 12 Mars 2011
à la Faculté des Sciences de Base
laboratoire SuperScience
programme doctoral en SuperScience
École Polytechnique Fédérale de Lausanne
pour l'obtention du grade de Docteur ès Sciences
par

Paolino Paperino

acceptée sur proposition du jury:

Prof Name Surname, président du jury
Prof Name Surname, directeur de thèse
Prof Name Surname, rapporteur
Prof Name Surname, rapporteur
Prof Name Surname, rapporteur

Lausanne, EPFL, 2011

Wings are a constraint that makes
it possible to fly.
— Robert Bringhurst

To my parents...

Acknowledgements

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Lausanne, 12 Mars 2011

D. K.

Preface

A preface is not mandatory. It would typically be written by some other person (eg your thesis director).

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Lausanne, 12 Mars 2011

T. D.

Abstract

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Zusammenfassung

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Résumé

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Contents

Acknowledgements	v
Preface	vii
Abstract (English/Français/Deutsch)	ix
List of figures	xv
List of tables	xvii
1 Introduction	1
2 Visualisation of non-gridded data	3
2.1 sensor data	3
2.2 experimental setups	3
2.3 Image rendering techniques	3
2.3.1 Heat equations	4
2.3.2 Triangulation with Delaunay	4
3 Z axis limitations	5
3.1 fast z feedback	5
3.2 tilt compensation	5
4 Results	7
4.1 Calcite experiment	7
4.2 Soft sample	7
A An appendix	9
Bibliography	11



List of Figures



List of Tables

1 Introduction

Limitations

Microscopy: - optical -> video rate but crappy resolution - EM -> rasterscan can slow electron beam fast - AFM -> slow mostly because of bulky mechanics: inertia (mass of the system), toshi ando small piezos (small range) but fast

Using spiral has been shown to be better(demands less BW x,y) but need display of non gridded data (lower res. freq. system)

z is still limiting to go on large scales (x,y)

2 Visualisation of non-gridded data

Most of the current AFM technologies work under the following principle: projecting two-dimensional data on a N by M grid. A system of controllers is needed to position the cantilever at the right spot (center of a grid element). With this method, the actual position on the XY plane is unprecise and directly correlated with the efficiency of the position controller. By taking the acquired z-data and assuming that the cantilever was actually on the right spot, we can construct a two-dimensional image of the surface. One can already see the problems induced by this method: limitation by the controllers(speed and precision). Moreover, putting data on a grid forces the scan pattern to be raster. It is simple to project a raster pattern on a 2D grid. Finally, hysteresis problems in the piezos is an additional imprecision in the system. We'll see how we can use position sensors on the XY-plane and different scan pattern to solve this problem.

2.1 sensor data

(problem of hyst solved) - graph of hyst - kalman (bit noise)

2.2 experimental setups

- MFP3D: capacity based - Homebuilt - attocube: interferometer

2.3 Image rendering techniques

- OpenGL and heat equations - benchmarking

Current AFMs give discrete data about the cantilever's position; therefore, we'll need to use image processing algorithms to generate images. The process of restoring unknown images is called inpainting. Indeed, it was mainly used to restore missing pieces in old paintings or photos. The principle behind inpainting is to fill a patch with its surroundings. A perfect

example of inpainting is removing an undesirable object from a picture. Also, we can use these algorithms to generate images from a cloud of points.

2.3.1 Heat equations

The heat equation represents the distribution of heat in a region over time.

$$\frac{\partial u}{\partial t} - \alpha \nabla^2 u = 0 \quad (2.1)$$

α is the thermal diffusivity - that is interpreted as a "thermal inertia modulus" - and u is the temperature over space and time (i.e. $u(x, y, z, t)$). A high thermal implies that the heat moves rapidly.

2.3.2 Triangulation with Delaunay

The principle behind the Delaunay triangulation is to generate triangles from triplets of point. The goal of the algorithm is to minimize the angles of each triangle. The triangulation is successful if no vertex (i.e. 3-dimensional point) is in the interior of a triangle.

Triangle.c is a powerful library developped by Jonathan Shewchuk to generate Delaunay triangulations. In our case, we'll only use the triangulation program on the first two dimensions of the 3d cloud of points. Indeed, we'll only render triangles on the 2D plane.

The next step is the coloring of the data. We use the z-data to render the color of the image.

3 Z axis limitations

3.1 fast z feedback

3.2 tilt compensation

4 Results

4.1 Calcite experiment

In this experiment we've observed the dissolution of calcite ($CaCO_3$) with water. This experiment is interesting

4.2 Soft sample

A An appendix

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.



Bibliography