

SHAPE MATCHING IN HIGHER DIMENSIONS

(Formenvergleich in höheren Dimensionen)

Dissertation zur Erlangung des Doktorgrades

vorgelegt am

Fachbereich Mathematik und Informatik
der Freien Universität Berlin

2002

von

Carola Wenk

Institut für Informatik
Freie Universität Berlin
Takustr. 9
D-14195 Berlin
Germany
wenk@inf.fu-berlin.de

Betreuer: Prof. Dr. Helmut Alt
Institut für Informatik
Freie Universität Berlin
Takustr. 9
D-14195 Berlin
Germany
alt@inf.fu-berlin.de

Gutachter: Prof. Dr. Helmut Alt
Institut für Informatik
Freie Universität Berlin
Takustr. 9
D-14195 Berlin
Germany
alt@inf.fu-berlin.de

Prof. Dr. Boris Aronov
Dept. of Computer and Information Science
Polytechnic University
Six MetroTech Center
Brooklyn, NY 11201
USA
aronov@ziggy.poly.edu

Vorlage zur Begutachtung: 15. Juli 2002
Termin der Disputation: 16. Dezember 2002

Contents

1	Introduction	1
1.1	Overview	1
1.2	Credits	2
2	Preliminaries	3
2.1	Representation of Shapes	3
2.2	Distance Measures	4
2.3	Miscellaneous	7
3	Hausdorff Distance Under Translations	9
3.1	Overview	9
3.1.1	Problem Statement	9
3.1.2	Known Results	10
3.1.3	Our Contribution	12
3.2	Basic Properties of $\vec{\delta}_H$	13
3.3	Matching Points to Sites	15
3.4	Matching Two Sets of Sites	22
3.4.1	Decision Problem	22
3.4.2	Arrangements of Volume Representations	23
3.4.3	Optimization	24
3.4.4	Lower Bounds	24
3.5	Approximate Algorithms	25
3.5.1	Reference Point Methods	27
3.5.2	Sampling and Pinning	28
4	Matching Special Shape Classes Under Translations	31
4.1	Matching Terrains	31
4.1.1	Perpendicular Distance	31
4.1.2	Directed Hausdorff Distance	34
4.2	Matching Convex Polyhedra	40
5	Matching Curves with respect to the Fréchet Distance	45
5.1	Basic Properties of the Fréchet Distance	47
5.2	Polygonal Curves Under Translations	50
5.2.1	Continuity	50
5.2.2	Clampings and Configurations	51
5.2.3	Arrangement of Critical Translations	53

5.2.4	Parametric Search	58
5.3	Polygonal Curves Under Affine Transformations	60
5.3.1	Arrangement of Critical Transformation Parameters	60
5.3.2	Specific Transformation Classes	62
5.4	Variants	64
5.4.1	Weak Fréchet Distance	64
5.4.2	Closed Curves and Partial Matching	65
5.4.3	A Lower Bound	66
6	Matching a Polygonal Curve in a Graph of Curves	69
6.1	Problem Statement	69
6.2	Algorithm	71
6.2.1	Basic Concepts and Overview	71
6.2.2	Preprocessing	73
6.2.3	Dynamic Programming	76
6.2.4	Path Reconstruction	78
6.2.5	Time Analysis	79
6.2.6	Parametric Search	80
6.2.7	Implementation	81
6.3	Variants	81
6.3.1	Start and End in the Middle of Segments	81
6.3.2	Avoiding U-Turns	82
6.3.3	Time-Space-Trade-Off	82
	Bibliography	89
	Index	95
	A Zusammenfassung	99
	B Lebenslauf	101