

Table of Contents

1	Introduction	1
1.1	Problem Statement	3
1.2	Research Focus	5
1.3	Organization of the Dissertation	6
2	Previous Related Work	7
2.1	Mesh Representations	7
2.2	Image Sampling Techniques	9
2.2.1	Sampling all the Original Pixels	9
2.2.2	Sampling a Predefined Number of Pixels	9
2.2.2.1	Uniform Sampling	10
2.2.2.2	Non-Uniform Sampling	10
2.2.3	Sampling a Non-Predefined Number of Pixels	11
2.3	Data Triangulation Techniques	12
2.3.1	2D Triangulation	13
2.3.1.1	Two Dimensional Triangulation without Optimization	13
2.3.1.2	Two Dimensional Triangulation with Optimization	13
2.3.2	$2\frac{1}{2}$ D Triangulation	15
2.3.2.1	$2\frac{1}{2}$ D Triangulation without Optimization	16
2.3.2.2	$2\frac{1}{2}$ D Triangulation with Optimization	17
2.3.3	3D Triangulation	17
2.3.3.1	Three Dimensional Triangulation without Optimization	17
2.3.3.2	Three Dimensional Triangulation with Optimization	18
2.4	Generation of Adaptive Triangular Meshes from Images	18

TABLE OF CONTENTS

2.5	Generation of Images from Triangular Meshes	19
2.6	Triangular Mesh Processing	20
2.6.1	Decimation of Triangular Meshes	20
2.6.2	Refinement of Triangular Meshes	22
2.6.3	Smoothing of Triangular Meshes	23
2.6.4	Segmentation of Triangular Meshes	24
2.6.5	Warping of Triangular Meshes	24
2.6.6	Integration of Triangular Meshes	25
2.6.7	Compression of Triangular Meshes	26
2.7	Manipulation of Compressed Images	26
3	Approximation and Generation of Digital Images Using Adaptive Triangular Meshes	29
3.1	Introduction	30
3.2	Basic Definitions	31
3.3	Image Approximation with Adaptive Triangular Meshes	33
3.3.1	Approximation of Digital Images with Bounded Error Adaptive Triangular Meshes	34
3.3.1.1	Initial Adaptive Triangulation	35
	Image Adaptive Sampling	35
	$2^{1/2}$ D Triangulation of Sampled Pixels	44
3.3.1.2	Generation of the Approximating Image	45
3.3.1.3	Determination and Resampling of Error Regions	45
3.3.1.4	Delaunay Retriangulation	47
3.3.1.5	Experimental Results	48
3.3.2	Approximation of Digital Images with Discontinuity-Preserving Adaptive Triangular Meshes	53
3.3.2.1	Image Adaptive Sampling	53
	Edge Adaptive Sampling	53
	Region Adaptive Sampling	56
3.3.2.2	Triangular Mesh Generation	58
3.3.2.3	Experimental Results	59
3.4	Image Generation from Adaptive Triangular Meshes	64
3.4.1	Generation of the Approximating Image: Geometric Uniform Sampling	65
3.4.2	Generation of the Approximating Image: Z-buffering	67
3.5	Summary	68

4 Geometric Processing of Adaptive Triangular Meshes:	
Analysis Operations	71
4.1 Introduction	72
4.2 Preprocessing Operations upon $2^{1/2}$ D Triangular Meshes	72
4.2.1 Geometric Transformations	73
4.2.1.1 Rotation and Translation of Triangular Meshes	74
4.2.1.2 Scaling, Shrinking and Stretching of Triangular Meshes	76
4.2.1.3 Deformation of Triangular Meshes	78
4.2.1.4 Experimental Results	78
4.2.2 Thresholding of Triangular Meshes	81
4.2.2.1 Single Dissection of a Triangular Mesh	81
4.2.2.2 Triangular Mesh Generation	84
4.2.2.3 Experimental Results	85
4.2.3 Quantization of Triangular Meshes	87
4.2.3.1 Multiple Dissection of a Triangular Mesh	89
4.2.3.2 Triangular Mesh Generation	90
4.2.3.3 Experimental Results	92
4.2.4 Algebraic Operations upon $2^{1/2}$ D Triangular Meshes	95
4.2.4.1 Arithmetic Operations: Addition and Subtraction	95
Determination of the Intersection Bounding Box	98
Generation of Intersection Regions	98
Generation of the Triangular Mesh	100
Experimental Results	100
4.2.4.2 Logic Operations: AND, NAND, OR, NOR, XOR and NOT	103
Logic Operations Among Polygons	105
Triangular Mesh Generation	109
Experimental Results	110
4.2.5 Selection of Regions-of-Interest from Triangular Meshes	111
4.2.5.1 Dissection of a Region-of-Interest in a Triangular Mesh	111
4.2.5.2 Generation of the Final Triangular Mesh	112
4.2.5.3 Experimental Results	113
4.2.6 Generation of Synthetic Triangular Meshes	114
4.3 Edge Detection upon $2^{1/2}$ D Triangular Meshes	117
4.3.1 Labeling of Edge Triangles	117
4.3.2 Intensity Smoothing in Labeled Triangles	119
4.3.3 Experimental Results	120
4.4 Segmentation of $2^{1/2}$ D Triangular Meshes	122

TABLE OF CONTENTS

4.4.1	Region Growing	124
4.4.2	Experimental Results	125
4.5	Feature Extraction upon Binary $2^{1/2}$ D Triangular Meshes	127
4.5.1	Binary Object Features	128
4.6	Histogram Generation upon $2^{1/2}$ D Triangular Meshes	133
4.7	Summary	134
5	Geometric Processing of Adaptive Triangular Meshes: Enhancement Operations	139
5.1	Introduction	140
5.2	Modification Operations upon Triangular Meshes	140
5.2.1	Gray-Scale Modification	140
5.2.1.1	Double Dissection of a Triangular Mesh	141
5.2.1.2	Mapping of z Coordinate Values	141
5.2.1.3	Triangular Mesh Generation	142
5.2.1.4	Experimental Results	143
5.2.2	Histogram Modification	145
5.2.2.1	Histogram Stretching	145
5.2.2.2	Histogram Shrinking	146
5.2.2.3	Histogram Sliding	146
5.2.2.4	Experimental Results	148
5.3	Filtering Operations upon $2^{1/2}$ D Triangular Meshes	150
5.3.1	Mean and Median Filters	151
5.3.2	Experimental Results	153
5.4	Summary	154
6	Summary and Contributions	157
6.1	Summary	157
6.1.1	Approximation of Digital Images with $2^{1/2}$ D Adaptive Triangular Meshes	158
6.1.2	Generation of Digital Images from $2^{1/2}$ D Adaptive Triangular Meshes	159
6.1.3	Image Analysis Operations upon $2^{1/2}$ D Adaptive Triangular Meshes	159
6.1.4	Image Enhancement Operations upon $2^{1/2}$ D Adaptive Triangular Meshes	160

TABLE OF CONTENTS

6.2	General Contributions	160
6.2.1	Efficient Generation of $2^{1/2}$ D Adaptive Triangular Meshes from Digital Images	160
6.2.2	Efficient Generation of Digital Images from $2^{1/2}$ D Adaptive Triangular Meshes	161
6.2.3	Acceleration of Image Analysis Operations	161
6.2.4	Acceleration of Image Enhancement Operations	162
6.2.5	Application of Image Analysis and Enhancement Operations to $2^{1/2}$ D Triangular Meshes Representing Arbitrary Surfaces	162
6.3	Future Work	162
6.3.1	Automatic Pixel Sampling Over Digital Images	163
6.3.2	Fast Constrained Triangular Mesh Generation	163
6.3.3	Generalization to Arbitrary 3D Triangular Meshes	163
6.3.4	Development of New Image Processing and Computer Vision Operations upon Triangular Meshes	164
6.3.5	Compression of Adaptive Triangular Meshes	164
7	References	165

