

## TABLE OF CONTENTS

	<u>Page</u>
ACKNOWLEDGMENTS.....	v
ABSTRACT .....	vii
LIST OF FIGURES.....	xiv
LIST OF CODE FRAGMENTS .....	xx
Chapter	
1. INTRODUCTION TO RAY TRACING .....	1
1.1 Introduction .....	1
1.2 Solid Modeling Techniques.....	2
1.2.1 Fundamentals.....	2
1.2.2 Constructive Solid Geometry (CSG) .....	4
1.2.3 Spatial Decomposition.....	8
1.2.4 Boundary Representation Method (B-rep) .....	12
1.2.5 Summary.....	15
1.3 Viewing System.....	16
1.3.1 Introduction.....	16
1.3.2 Synthetic Camera Model.....	16
1.3.3 Projection Techniques.....	20
1.3.3.1 Perspective Projection.....	23
1.3.3.2 Parallel Projection .....	23
1.4 Polygonal Shading Techniques.....	24

1.4.1	Image Rendering Techniques .....	24
1.4.2	Hidden surface removal algorithms .....	28
1.4.3	The Illumination Model .....	31
1.4.4	Various Shading Techniques .....	34
1.5	Ray Tracing Technique .....	38
1.5.1	Generating More Realistic Images by the Ray Tracking Method.....	38
1.5.2	Ray-Object intersection Tests .....	41
1.5.3	Secondary Rays .....	43
1.5.4	The Aliasing Problem.....	51
1.6	Summary .....	53
2.	SURVEY OF RAY TRACING ACCELERATION TECHNIQUES.....	55
2.1	Introduction .....	55
2.2	Faster Intersection Techniques .....	60
2.2.1	Bounding Volumes and Hierarchies .....	60
2.2.1.1	Evolution and Definition.....	60
2.2.1.2	Construction and Optimization of Bounding Volume Hierarchies .....	63
2.2.1.3	Bounding Volume Selection.....	66
2.2.1.4	Summary.....	73
2.2.2	3-D Spatial Subdivision.....	74
2.2.2.1	Introduction.....	74
2.2.2.2	Regulative Spatial Subdivision -- Octree technique and its variation.....	76
2.2.2.3	Irregular Spatial Subdivision -- Binary Space Partition method .....	87
2.2.2.4	Caveats in Spatial Subdivision Techniques .....	90
2.2.3	Directional Techniques.....	92
2.2.3.1	The Directional Cube .....	92
2.2.3.2	The Light Buffer .....	97
2.2.3.3	Ray Classification.....	100

2.3	Ray Tracing using the Statistical Sampling Method - Fewer Rays Techniques .....	104
2.4	Generalized Rays.....	106
2.4.1	Introduction.....	106
2.4.2	Cone Tracing .....	107
2.4.3	Beam Tracing.....	110
2.4.4	Pencil Tracing.....	113
2.5	Summary .....	116
3.	MULTI-CAMERA RAY TRACING TECHNIQUES.....	118
3.1	Introduction .....	118
3.1.1	Spatial Subdivision Technique in the 3-D World .....	118
3.1.2	Multi-camera Method in the 2-D Space .....	120
3.2	Projection Extents and the Partition Planes .....	122
3.2.1	The Orthographic Projection.....	122
3.2.1.1	Orthographic Projection vs. Perspective Projection .....	123
3.2.1.2	The Synchronization Problem.....	125
3.2.2	Extending the Projection Scheme .....	128
3.2.2.1	The Bounding Polyhedron .....	128
3.2.2.2	The Projection Extent .....	130
3.2.2.3	The Virtual Partition Planes .....	132
3.2.3	Summary.....	134
3.3	Ray Tracking with the Virtual Partition Planes - the Slab Method .....	135
3.3.1	Defining Slabs from the Virtual Partition Planes.....	136
3.3.2	The Multiple Cameras Technique with Slabs.....	137
3.3.3	Summary.....	149
3.4	Ray Tracking with the Boundary Mesh -- the Cell Method .....	150

3.4.1	Defining Boundary Mesh from the Virtual Partition Planes .....	151
3.4.2	Construction of the Boundary Mesh .....	153
3.4.3	The Multiple Cameras Technique with Boundary Mesh ....	159
3.4.4	Summary.....	166
3.5	Ray Tracking with Block Mesh -- the Block Method.....	167
3.5.1	Block Table and Block Mesh.....	168
3.5.2	An Example of Constructing the Block Table and the Block Mesh .....	173
3.5.3	The Algorithm to Construct the Block Table and the Index Mesh .....	177
3.5.4	Tracking a Ray on the Index Mesh using the Block Table.....	185
3.5.5	Summary.....	194
3.6	Conclusion.....	195
3.6.1	S-bound Method .....	195
3.6.2	Self-shadowing Quick Test .....	197
3.6.3	Summary.....	198
4.	EXPERIMENTS AND ANALYSIS .....	199
4.1	Quest of the Multi-Camera Technique .....	199
4.1.1	Outline of Questions.....	199
4.1.2	Working Computer Environment and Tools .....	205
4.1.3	The Ray-Bounding Box Algorithm.....	207
4.1.4	Notations in Tables .....	211
4.1.4.1	Notations of Quantities.....	211
4.1.4.2	Relations Between these Quantities.....	213
4.2	Experiments .....	215
4.2.1	Test Scenes .....	215
4.2.2	Table of Contents for the Experiments .....	216
4.2.3	Ray Tracing With the Multi-Camera Method .....	217
4.2.3.1	How Many Cameras are Enough ?.....	217
4.2.3.2	Experiments and Results .....	219

4.2.4	Angles Between Two Referee Cameras .....	230
4.2.5	Orientation of the Referee Camera.....	241
4.2.6	Variations of the Multi-Camera Technique .....	252
4.3	Conclusion.....	266
4.4	Future work .....	268

## APPENDICES

A.	SAMPLE CODES .....	270
B.	TEST SCENES.....	292
	BIBLIOGRAPHY .....	299