

Contents

1	Introduction	1
1.1	Problem	3
1.2	Contribution	5
1.3	Overview	7
2	Related Work	9
2.1	Object Detection	9
2.1.1	Segmentation	9
2.1.2	Exhaustive Search	10
2.1.3	Superficial Search	10
2.2	Trajectory Extraction	11
2.2.1	3D Object Tracking	11
2.2.2	3D Trajectory Extraction from Surveillance Videos	13
2.2.3	3D Trajectory Extraction from Moving Cameras	14
2.3	Camera Parameters Estimation	14
2.3.1	Focal Length Estimation	16
2.3.2	Camera Odometry Estimation	16
2.4	Trajectory Analysis	17
2.4.1	Convoy Detection	18
2.4.2	Suspicious Activity Detection	18
3	Object Detection	21
3.1	Object Detection in Surveillance Videos	22
3.1.1	Clustering for One Frame	22
3.1.2	Clustering Improvement for a Frame Sequence	23
3.2	Object Detection in Still Images	24
3.2.1	Systematic Search	25
3.2.2	Classification	26

3.3	Summary	27
4	3D Trajectory Extraction from Surveillance Videos	29
4.1	Initialisation	30
4.2	Best Frame Selection	31
4.3	Particle Filter	32
4.3.1	Transition Distribution	34
4.3.2	Weight Computation	35
4.4	Coordinate Conversion	37
4.5	Summary	38
5	3D Trajectory Extraction from Moving Cameras	39
5.1	Focal Length Estimation	43
5.2	Object's Depth Estimation	45
5.3	Observation Model	45
5.3.1	Camera Observation	46
5.3.2	Object Observation	48
5.4	Motion Model	51
5.4.1	Camera Motion	52
5.4.2	Object Motion	52
5.5	Sampling	56
5.5.1	Object Birth	57
5.5.2	Object Death	58
5.5.3	Object Stay	58
5.5.4	Object Exit	58
5.5.5	Object Update	59
5.5.6	Camera Update	59
5.6	Summary	59
6	Application: Trajectory Analysis	61
6.1	Convoy Detection	61
6.1.1	Noncontinuous Convoy:	62
6.1.2	Clustering and Intersection:	62
6.1.3	Candidate Expiring Mechanism:	63
6.2	Suspicious Activity Detection	64
6.3	Summary	70

7 Experiments and Results	73
7.1 Object Detection	73
7.1.1 Object Detection in Surveillance Videos	73
7.1.2 Object Detection in Still Image	75
7.2 3D Trajectory Extraction	78
7.2.1 3D Trajectory Extraction from Surveillance Videos	78
7.2.2 3D Trajectory Extraction from Moving Cameras	83
7.3 Camera Parameters Estimation	89
7.3.1 Focal Length Estimation	89
7.3.2 Camera Odometry Estimation	95
7.4 Trajectory Analysis	99
7.4.1 Convoy Detection	99
7.4.2 Suspicious Activity Detection	102
8 Conclusion	105
8.1 Summary	105
8.2 Future Work	107
Abbreviations	109
Mathematical Symbols	111
List of Figures	113
List of Tables	117
List of Algorithms	119
Bibliography	121
Own Publications	133
Curriculum Vitae	135