

Contents

1	Introduction	1
1.1	Automatic Detection and Identification of Parasite Eggs	4
1.2	Typical Approach for the Automated System	6
1.2.1	Parasite Egg Images	6
1.2.2	Pre-Processing of Input Image	8
1.2.3	Segmentation	10
1.2.4	Feature Extraction	10
1.2.5	Classification	12
1.3	Issues and Challenges	12
1.4	Objective of the Thesis	14
1.5	Thesis Organization	15
2	Literature Survey	17
2.1	Parasite Egg Segmentation	17
2.1.1	Threshodling Based Approaches	18
2.1.2	Edge Detection Based Approaches	22
2.1.3	Edge Detection using Wavelet Transform	24
2.1.4	Active Contour Model (ACM)-based Approaches	27

2.1.5	Watershed Algorithm-based Segmentation	29
2.1.6	Clustering-based Segmentation Approaches	32
2.1.7	Ellipse Matching-based Approaches	33
2.1.8	Segmentation using Convolutional Neural Network (CNN) models	35
2.2	Feature Extraction and Classification of Parasite Egg	38
2.3	CNN-based Classification and Object Detection methods used in Parasite Egg Identification	45
2.4	Conclusion	48
3	Dataset of Microscopic Images of Parasite Eggs and Ground Truths	50
3.1	Dataset for traditional image segmentation	51
3.2	Dataset for classification	53
3.3	Dataset for deep learning-based segmentation	54
3.4	Dataset for Deep Learning-Based Object Detection	57
3.5	Conclusion	58
4	Segmentation of Microscopic Images of Parasite Eggs	60
4.1	Effectiveness of Traditional Methods for Segmenting Parasite Egg Images	60
4.1.1	Analysis of Thresholding-Based Segmentation Method	65
4.1.2	Analysis of Edge-Detection-Based Segmentation	67
4.1.3	Analysis of watershed-based segmentation	68
4.1.4	Analysis of Clustering-Based Segmentation	70
4.2	Proposed Segmentation Approach	71

4.2.1	Pre-Processing and Edge Detection	72
4.2.2	Post-Processing	72
4.3	Results and Discussion	74
4.4	Conclusion	76
5	Extraction of Features from the Segmented Objects	77
5.1	Image Moment-Based Features	78
5.1.1	Hu Moments	79
5.1.2	Legendre Moments	80
5.1.3	Chebyshev Moments	81
5.1.4	Krawtchouk moments	83
5.2	Texture and Shape-based Features	85
5.2.1	Grey-Level Co-occurrence Matrix	86
5.2.2	Haralick Texture Features	87
5.2.3	Shape-based Descriptors	89
5.2.4	Pixel Intensity-based Feature	90
5.3	Conclusion	92
6	Identification of Parasite Eggs using Machine Learning Algorithms	93
6.1	Classification Using Four Classes of Objects	95
6.1.1	Classification Results Obtained Using Image Moments	95
6.1.2	Classification using Texture and Shape-based Features	104
6.1.3	Classification using Pixel Intensity-based Features	106
6.1.4	Classification Using Combinations of Different Feature Sets	108

6.2	Classification using Multiple Classes of Non-Egg Objects	111
6.3	Result Analysis and Discussion	118
6.4	Comparison with Previous Works	119
6.5	Conclusion	122
7	Deep Learning-based Approaches for Segmentation, Detection and Classification of Parasite Eggs from Microscopic Images	124
7.1	Segmentation of Parasite Egg Images using CNN-based Models . . .	125
7.1.1	Training U-Net using Transfer Learning Approach	125
7.1.2	Training UNet with Random Weights	126
7.1.3	Training UNet using Multi-Class Object	128
7.2	Classification of Parasite Eggs Using CNN models	128
7.2.1	Training CNN model using Transfer Learning Technique . .	130
7.2.2	Training a custom CNN model	130
7.2.3	Analysis of Classification Results	134
7.2.4	Comparison of Classification Result with Previous Works . .	137
7.3	CNN-based Object Detection Technique for Parasite Egg Detection	137
7.3.1	Comparison of Object Detection Result with Previous Works	140
7.4	Conclusion	141
8	Conclusion and Future Direction	142
8.1	Conclusion	142
8.2	Future Direction	146
	Publications based on the Thesis Works	162