

Table of Contents

S. No.	Description	Page No.
a)	List of Tables	xiii
b)	List of Figures	xv
c)	List of Abbreviations	xviii
d)	Preface	xx
1.0	Chapter 1: Introduction	1
1.1	Challenges in the Medical Imaging	2
1.2	Motivation for MR imaging	3
1.3	Objective of the Thesis	5
1.4	Contribution of the Thesis	6
1.5	Organisation of the Thesis	6
2.0	Theoretical Background	9
2.1	Segmentation using deep learning based methods	9
2.2	Denoising using deep learning based methods	13
2.3	Classification using deep learning based methods	16
2.4	Transfer learning for image processing	18
3.0	Automatic Segmentation of Brain Tumour in Magnetic Resonance Images using an Enhanced Deep Learning Approach	21
3.1	Introduction	22
3.2	Methodology	24

3.3	Clinical external validation of the segmented data and acquisition of dataset	28
3.4	Dataset Acquisition	28
3.5	Results	29
3.5.1	Results obtained when network was trained and tested on the Kaggle data	29
3.5.1.1	Results obtained from 50 epochs of training	29
3.5.1.2	Results obtained from 100 epochs of training	30
3.5.2	Results obtained when network was trained on Kaggle data and tested fig share dataset	31
3.6	Discussion	33
3.7	Conclusion	36
4.0	Computer Based Segmentation of Cancerous Tissues in Biomedical Images using Enhanced Deep Learning Model	37
4.1	Introduction	38
4.2	Methodology	40
4.2.2	External clinical validation of the segmented result:	45
4.2.3	Dataset acquisition	45
4.3	Results	46
4.3.1	Results obtained for Brain Tumour Datasets	46
4.3.2	Results obtained for Skin Cancer Datasets	48
4.4	Discussion	49
4.4.1	Quantitate Analysis	49
4.4.2	Performance Analysis	50
4.4.3	Qualitative Analysis	51
4.5	Conclusion	52

5.0	An Augmented Deep Learning Network with Noise Suppression feature for Efficient Segmentation of Cardiac MR Images	53
5.1	Introduction	54
5.2	Methodology	56
5.2.1	Experimental Setup	61
5.2.2	Datasets and Evaluation Metrics	62
5.3	Results	63
5.3.1	Results obtained from heart segmentation ACDC dataset	64
5.3.2	Results obtained from heart segmentation SCD dataset	65
5.3.3	Ablation Study	67
5.4	Discussion	69
5.5	Conclusion	70
6.0	Denoising of Magnetic Resonance Images Using Discriminative Learning-Based Deep Convolutional Neural Network	71
6.1	Introduction	72
6.1.1	Nature of Rician noise	73
6.2	Methodology	74
6.2.1	Clinical external validation of the denoised data	79
6.2.2	Testing the applicability of denoised data by segmentation	79
6.2.3	Comparison with other methods	79
6.2.3.1	Weighted Nuclear Norm Minimization (WNNM) Method	80
6.2.3.2	Non-local Means (NLM) Denoising Method	80
6.2.3.3	Denoising Convolutional Neural Network (DnCNN)	80
6.3	Dataset acquisition	80
6.4	Results	81

6.4.1	Results of Brain web dataset	81
6.4.2	Results from IXI-Guys dataset	82
6.4.3	Results of denoised segmented images	84
6.5	Discussion	85
6.6	Conclusion	108
7.0	Deep Learning and Transfer Learning based Approaches for Classification of Medical Images.	89
7.1	Introduction	90
7.2	Methodology	93
7.3	Dataset Acquisition and Evaluation Metrics	100
7.3.1	Dataset Used	100
7.3.2	Evaluation of dataset	100
7.4	Results	102
7.5	Discussion	105
7.6	Transfer Learning Based Approach for Classification of Covid-19 infected images	108
7.6.1	Methodology	108
7.6.2	Transfer Learning	109
7.6.3	MobileNet V2 architecture	110
7.6.4	Dataset Used	113
7.6.4.1	X-ray Dataset	113
7.6.4.2	CT Dataset	113
7.6.5	Results	113
7.6.6	Discussion	154
7.6.6.1	Quantitative Analysis	154
7.6.7	Conclusion	158

8.0	Conclusion and Future scope	123
8.1	Conclusion	123
8.2	Future Scope	124
	References	127
	Author's List of Publications (on PHD Work)	157

List of Tables

Table No.	Description	Page No.
2-1	Selected previous significant work for segmentation of medical images.	12
2-2	Selected previous significant work for image denoising	14
2-3	Selected previous significant work for classification of images	17
2-4	Selected previous significant work on Transfer Learning.	19
3-1	Parameter comparison of the networks for 50 epochs of training	30
3-2	Parameter comparison of the networks for 100 epochs of training	31
3-3	Parameter comparison of the networks for 50 epochs of training when network is trained on kaggle dataset and tested on figshare dataset	33
3-4	Parameter comparison of the networks for 100 epochs of training when network is trained on kaggle dataset and tested on figshare dataset.	33
4-1	Comparison of evaluation metrics when the network was trained and tested on Kaggle dataset.	47
4-2	Comparison of evaluation metrics when the network was trained on Kaggle dataset and tested on Figshare dataset.	47
4-3	Comparison of evaluation metrics when the network was trained on Kaggle dataset and tested on IMS-BHU dataset.	47
4-4	Comparison of evaluation metrics when the network was trained and tested on ISIC 2016 dataset.	48
4-5	Comparison of evaluation metrics when the network was trained on ISIC 2016 dataset and tested on ISIC 2018 dataset.	49
5-1	Evaluation Metrics Comparison for ACDC dataset.	65
5-2	Evaluation Metrics Comparison for SCD dataset.	67
5-3	Ablation Study: Evaluation Metrics Comparison of SCD dataset for noise free original images.	68

5-4	Ablation Study: Evaluation Metrics Comparison of SCD dataset for 7% noise corrupted images	68
6-1	Results of Friedman Test showing the mean ranks of the methods.	84
6-2	Statistical analysis results using Wilcoxon signed rank test with $\alpha = 0.05$.	84
6-3	Comparison of segmentation evaluation metrics.	85
7-1	The PCC values for GLCM.	99
7-2	The PCC values for LBP.	99
7-3	Global Accuracies of the classifiers	103
7-4	Mean ranks determined using Friedman Test.	105
7-5	Results of Wilcoxon signed rank test with $\alpha = 0.05$.	105
7-6	Evaluation metric comparison of CT images.	114
7-7	Evaluation metric comparison of X-Ray images.	114
7-8	Evaluation metric comparison of CT images with expected low values.	114
7-9	Evaluation metric comparison of X-Ray images with expected low values.	115

List of Figures

Figure No.	Description	Page No.
2.1	(a) Block diagram for the flow of Segmentation Process. (b) Block diagram for the flow of Denoising Process. (c) Block diagram for the flow of Classification Process.	20
3.1	The architecture of CCN-PR-Seg-net segmentation network.	25
3.2	Segmentation results when network was trained on Kaggle dataset and tested on same dataset (a) original image, (b) segmentation mask, (c) seg-net output, (d) u-net output, (e) CCN-PR-seg-net output for 50 epochs of training.	29
3.3	Segmentation results when network was trained on Kaggle dataset and tested on same dataset (a) original image, (b) segmentation mask, (c) seg-net output, (d) u-net output, (e) CCN-PR-seg-net output for 100 epochs of training.	30
3.4	Segmentation results when the network was trained on Kaggle dataset and tested on figshare dataset (a) original image, (b) segmentation mask, (c) seg-net output, (d) u-net output, (e) CCN-PR-seg-net output for 50 epochs of training.	32
3.5	Segmentation results when network was trained on Kaggle dataset and tested on figshare dataset (a) original image, (b) segmentation mask, (c) seg-net output, (d) u-net output, (e) CCN-PR-seg-net output for 100 epochs of training.	32
4.1	Architecture of the proposed network.	41
4.2	Depth wise Separable block with bottleneck connection	42
4.3	Functioning of layers in depthwise separable convolution block.	43
4.4	Depth wise Separable Convolution Functioning.	43
4.6	Results obtained when the network was trained and tested on kaggle dataset, (a) original image, (b) corresponding mask, (c) seg-net output, (d) u-net output, (e) proposed network output.	46
4.7	Results obtained when the network was trained on kaggle dataset and tested on Figshare dataset, (a) original image, (b) corresponding mask, (c) seg-net output, (d) u-net output, (e) proposed network output.	46

4.8	Results obtained when the network was trained on kaggle dataset and tested on IMS-BHU dataset, (a) original image, (b) corresponding mask, (c) seg-net output, (d) u-net output, (e) proposed network output.	47
4.9	Results obtained when the network was trained and tested on ISIC 2016 dataset, (a) original image, (b) corresponding mask, (c) seg-net output, (d) u-net output, (e) proposed network output.	48
4.10	Results obtained when the network was trained on ISCI 2016 dataset and tested on ISIC 018 dataset, (a) original image, (b) corresponding mask, (c) seg-net output, (d) u-net output, (e) proposed network output.	48
5.1	Modified Depth wise Separable block.	57
5.2	Architecture of the proposed network.	58
5.3	Segmentation results of ACDC dataset. First column (a)-(s) presents the mask of the image being segmented, first row (b)-(f) presents the original image and noisy version (1%,3%,5% and 7%) of the original image. Second, third and fourth rows presents the segmented results for Seg-Net (h)-(l), U-net (n)-(r) and proposed network (t)-(x) . Second, third, fourth, fifth and sixth column presents the segmented results for original (h)-(t), 1% (i)-(u), 3% (j)-(v), 5% (k)-(w) and 7% (l)-(x) noise corrupted images.	64
5.4	Segmentation results of SCD dataset. First column (a)-(s) presents the mask of the image being segmented, first row (b)-(f) presents the original image and noisy version (1%,3%,5% and 7%) of the original image. Second, third and fourth rows presents the segmented results for Seg-Net (h)-(l), U-net (n)-(r) and proposed network (t)-(x) . Second, third, fourth, fifth and sixth column presents the segmented results for original (h)-(t), 1% (i)-(u), 3% (j)-(v), 5% (k)-(w) and 7% (l)-(x) noise corrupted images.	66
5.5	Comparison of Specificity, Sensitivity and Precision for the networks. First to fifth bars of each metric presents results for original image, 1%, 3%, 5% and 7% noise corrupted images respectively.	66
5.6	Layout plan of Ablation study.	67
6.1	Depthwise Separable block with LRN	75
6.2	Architecture of the proposed denoising model.	77

6.3	Denoising results of network trained on Brainweb dataset (a) SSIM and (b) PSNR.	82
6.4	BrainWeb dataset denoising example: (a) original image, (b) with noise (c) NLM, (d) WNNM, (e) DnCNN, and (f) Proposed Model.	82
6.5	Denoising results of IXI-Guys dataset with network trained on IXI Guys dataset: (a) SSIM and (b) PSNR	83
6.6	IXI Guys dataset denoising example: (a) original image, (b) image with noise, the corresponding denoised image from (c) NLM, (d) WNNM, (e) DnCNN, and (f) Proposed Model.	83
6.7	The segmentation results of denoised images (a) noisy image (15%), (b) NLM, (c) WNNM, (d) DnCNN, (e) Proposed Model.	85
7.1	Architecture of proposed network.	93
7.2	Schematic pipeline of proposed network	96
7.3	Metrics comparison of covid-19 class (a) Accuracy, (b) F1-Score, (c) F0.5-score,(d) MCC,(e) FM Index and (f) BCR	103
7.4	Metrics comparison of normal class (a) Accuracy, (b) F1-Score, (c) F0.5-score,(d) MCC,(e) FM Index and (f) BCR.	104
7.5	Metrics comparison of viral pneumonia class (a) Accuracy, (b) F1-Score, (c) F0.5-score,(d) MCC,(e) FM Index and (f) BCR.	104
7.6	Pipeline of the proposed work	109
7.7	Feature transfer using transfer learning	110
7.8	Depth wise Separable convolution block.	111
7.9	Functioning of Mobile Net V2 model.	112
7.10	Mobile Net V2 architecture for classification.	112
7.11	Evaluation Metrics comparison of CT images.	115
7.12	Evaluation Metrics comparison of X-Ray images.	116