# Adaptive Self-learning Systems for Medical Image Analyses using Hybrid-Dense Convolutional Neural Network


DOCTOR OF PHILOSOPHY

IN

COMPUTER SCIENCE

Submitted By

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L1F16PHDC0002

DEPARTMENT OF COMPUTER SCIENCE

FACULTY OF INFORMATION TECHNOLOGY & COMPUTER SCIENCE

UNIVERSITY OF CENTRAL PUNJAB

May, 2023

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A thesis submitted in partial fulfillment

of the requirement for the degree of

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Supervised by

Dr. Adnan N. Qureshi

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# ABSTRACT

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# DEDICATION

To my beloved **father** who never saw this adventure.

# ACKNOWLEDGEMENTS

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Saeed Iqbal

# DECLARATION

I, Saeed Iqbal, S/O Muhammad Aslam, a student of "Doctor Of Philosophy in Computer Science" at "Department of Computer Science", "Faculty of Information Technology & Computer Science", University of Central Punjab, hereby declare that this thesis titled "Adaptive Self-learning Systems for Medical Image Analyses using Hybrid-Dense Convolutional Neural Network", is my own research work and has not been submitted, published, or printed elsewhere in Pakistan or abroad. Additionally, I will not use this thesis for obtaining any degree other than the one stated above.

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Name of Student: Saeed Iqbal

Registration Number: L1F16PHDC0002

Date: _____

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I, Saeed Iqbal, solemnly declare that the research work presented in this thesis titled, "Adaptive Self-learning Systems for Medical Image Analyses using Hybrid-Dense Convolutional Neural Network" is solely my research work, and that the entire thesis has been completed by me, with no significant contribution from any other person or institution. Any small contribution, wherever taken, has been duly acknowledged.

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It is certified that this thesis titled, "Adaptive Self-learning Systems for Medical Image Analyses using Hybrid-Dense Convolutional Neural Network", submitted by Saeed Iqbal, Registration No. L1F16PHDC0002, for Doctor Of Philosophy degree at "Department of Computer Science", "Faculty of Information Technology & Computer Science", University of Central Punjab, is an original research work and contains satisfactory material to be eligible for evaluation by the Examiner(s) for the award of the above stated degree.

**Supervisor's Name: Dr. Adnan N. Qureshi**

Associate Professor

Faculty of Information Technology & Computer Science

University of Central Punjab

_____

Signature

Date:

# CERTIFICATE OF EXAMINERS

It is certified that the research work contained in this thesis titled "Adaptive Self-learning Systems for Medical Image Analyses using Hybrid-Dense Convolutional Neural Network" is up to the mark for the award of Doctor Of Philosophy in Computer Science.

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Name: Dr. Iram Noreen

Date:_____

**External Examiner**

Signature:

Name: Dr. Mubashar Mushtaq

Date:_____

**Internal Examiner**

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Name: Dr. Muhammad Sarwar Ehsan

Date:_____

**Dean**

Department of Computer Science

Faculty of Information Technology & Computer Science

University of Central Punjab

Signature:

Name: Dr. Muhammad Amjad Iqbal

Date:_____

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# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **ABCD** | Asymmetry, Boundary irregularity, Color and Diameter |
| **ACM** | Active Contour Model |
| **AHT** | Adaptive Hyperparameter Tuning |
| **APPA** | Adversarial Pyramid Progressive Attention |
| **AUC** | Area Under Curve |
| **BCC** | Basal Cell Carcinoma |
| **BI** | Bilinear Interpolation |
| **BO** | Bayesian Optimization |
| **BraTS** | Brain Tumor Segmentation |
| **CAD** | Computer Aided Diagnosis |
| **CNN** | Convolutional Neural Network |
| **CT** | Computer Tomography |
| **CXR** | Chest X-ray |
| **DCT** | Discrete Cosine Transform |
| **DPN** | Dual Path Network |
| **DQN** | Deep Q-Networks |
| **DSC** | Dice Similarity Coefficient |
| **EI** | Expected Improvement |
| **EM** | Expectation Maximization |
| **FC** | Fully Connected |
| **FCM** | Fuzzy C-Means |
| **FLDA** | Fisher Linear Discriminant Analysis |
| **FPN** | Feature Pyramid Network |
| **GGO** | Ground Glass Opacity |
| **GLCM** | Gray Level Co-occurrence Matrix |
| **GLPP** | GLocal Pyramid Pattern |
| **GP** | Gaussian Process |
| **H&E** | Hematoxylin and Eosin |
| **HOG** | Histogram of Oriented Gradients |

| | |
|---|---|
| **JSRT** | Japanese Society of Radiological Technology |
| **KNN** | K-Nearest Neighbor |
| **LBP** | Local Binary Pattern |
| **LBPCNN** | Local Binary Pattern Convolutional Neural Network |
| **LO** | Label Optimizer |
| **LSM** | Level Set Method |
| **LSTM** | Long Short Term Memory |
| **MFCG** | Manual Feature based Classification and Segmentation |
| **NCC** | Normalized Cross Correlation |
| **NSCLC** | Non Small Cell Lung Cancer |
| **PC** | Papillary Carcinoma |
| **PT** | Phyllodes Tumor |
| **PVSSM** | Pixel Value Space Statistics Map |
| **RF** | Random Forest |
| **RLM** | Run Length Matrix |
| **RNN** | Recurrent Neural Network |
| **ROI** | Region of Interest |
| **RPN** | Region Proposal Network |
| **RT** | Radio-Therapy |
| **SAD** | Sum of Absolute Difference |
| **SCC** | Squamous Cell Carcinoma |
| **SCLC** | Small Cell Lung Cancer |
| **SCM** | Systematical Co-occurrence Matrix |
| **SE** | Structural Element |
| **SI** | Shape Index |
| **SIFT** | Scale-Invariant Feature Transform |
| **SSD** | Sum of Squared Difference |
| **SURF** | Speeded Up Robust Feature |
| **SVM** | Support Vector Machine |
| **SZM** | Size Zone Matrix |
| **TA** | Tubular Adenona |
| **TPE** | Tree Parzen Estimators |
| **WSI** | Whole-Slide Imaging |

# LIST OF SYMBOLS

| | |
|---|---|
| $\hat{y}$ | prediction or approximation value |
| $\theta$ | training model parameters |
| $\lambda$ | strength of regularization |
| $\eta$ | learning rate |
| $\kappa$ | Structural Element |
| $\mu$ | arithmetic mean |
| $\gamma$ | parameters for scaling |
| $\ell$ | lagrange multiplier |
| $\nabla$ | gradient of down-sampling |
| $\tau$ | testing dataset |
| $\sigma$ | variance |
| $\psi$ | saturation values |
| $\nu$ | stain vector |
| $\psi$, $\mathfrak{F}$ | activation function |
| $\hbar\prime$ | stain normalized image |
| $\sigma^2$ | statistical moment |
| $\aleph^o$ | magnified image |
| $\upsilon_{i,j}^l$ | input vector of a layer |
| $\eta_{img}$ | Top-Hat morphological operations |
| $\tau_{img}$ | Bottom-Hat morphological operations |
| $\varphi_m$ | mitotic or malignant region |
| $\varphi_o$ | background of a slice |
| $\nu_t$ | exponential averaged of gradient |
| $B$ | set of minibatch |
| $F$ | number of input channels |
| $T$ | training dataset |
| $\boldsymbol{C}_{\oplus}^{\prime}(p_i)$ | anti-clockwise features |
| $\boldsymbol{C}_{\oplus}(p_i)$ | clock-wise extracted features |

| | |
|---|---|
| $\boldsymbol{H(\varphi(x))}$ | Heaviside function for smoothness |
| $\boldsymbol{L}$ | Loss function |
| $\boldsymbol{P}$ | total neighbor pixel values |
| $\boldsymbol{R}$ | radius pixel values |
| $\boldsymbol{W}^{[i]}$ | CNN model parameters |
| $\boldsymbol{X}$ | input image |
| $\boldsymbol{a}_{fc}$ | actual cost |
| $\boldsymbol{b}$ | bias |
| $\boldsymbol{coord(\varphi)}$ | slice of an image |
| $\boldsymbol{g}_c$ | central value of gray images |
| $\boldsymbol{g}_p$ | neighbor value of gray images |
| $\boldsymbol{n}_{fc}$ | network predicted cost |
| $\boldsymbol{w}_i$ | random weights |
| $\boldsymbol{x}_i$ | represents variables (pixel values) |

# CHAPTER: ONE

# Preliminaries and Introduction

> "We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones to start with? Even this is a difficult decision. Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English. This process could follow the normal teaching of a child. Things would be pointed out and named, etc. Again I do not know what the right answer is, but I think both approaches should be tried."
>
> *– Alan Turing, Computing Machinery and Intelligence (1950)*

## 1.1 Introduction

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# CHAPTER: TWO

# Going Deep in Machine Learning

## 2.1 What is Deep Machine Learning?

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## 2.2 Summary

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# CHAPTER: THREE

# State of the Art

> "Let the future tell the truth and evaluate each one according to his work and accomplishments. The present is theirs, the future, for which I really worked, is mine."
>
> *– Nikola Tesla*

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# CHAPTER: FOUR

# Conclusions and Future Work

## 4.1 Conclusion

> "The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of a planter – for the future. His duty is to lay the foundation for those who are to come and point the way."
>
> *– Nikola Tesla*

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