Dedicated to my family and well wishers

Declaration

I do hereby declare that the thesis entitled "**Handcrafted and Deep Features for Biomedical Image Retrieval and Classification Applications**" being submitted to the Department of Electronics and Communication Engineering, School of Engineering, Tezpur University is a record of original research work carried out by me. All sources of assistance have been assigned due acknowledgement. I also declare that neither this work as a whole nor a part of it has been submitted to any University or Institute for award of any other degree or diploma. Any violation of the above declaration will take disciplinary action by the university.

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Certificate of the Supervisor

This is to certify that the thesis entitled "**Handcrafted and Deep Features for Biomedical Image Retrieval and Classification Applications**" submitted to the School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in the Department of Electronics and Communication Engineering is a record of research work carried out by Ms. Deepamoni Mahanta under my supervision and guidance.

All help received by her from various sources have been duly acknowledged. No part of this thesis has been submitted elsewhere for award of any other degree.

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Certificate of External Examiner

The examiners of Oral Defence Evaluation Committee (ODEC) certify that the thesis entitled "**Handcrafted and Deep Features for Biomedical Image Retrieval and Classification Applications**"submitted by Deepamoni Mahanta, research scholar, Department of Electronics and Communication Engineering, School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy, has been examined by us on ..... and found to be satisfactory.

Thereby, the committee recommends for the award of the degree of Doctor of Philosophy.

Supervisor
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External Examiner
(.....)

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Place: Tezpur, Assam, India

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(Deepamoni Mahanta), Place: Tezpur, Assam, India

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List of Acronyms

AI	Artificial intelligence
ARP	Average retrieval precision
ARR	Average retrieval recall
ACO	Ant colony optimisation
AUC	Area under the curve
BoW	Bag of words
BP	Bit-Plane
CT	Computed tomography
CXR	Chest X-ray
CAD	Computer-aided diagnosis
COVID-19	Coronavirus disease 2019
CBIR	Content based image retrieval
CNN	Convolutional neural network
CLAHE	Contrast-limited adaptive histogram equalization
CSLBCoP	Centre symmetric local binary co-occurrence pattern
CLBP	Completed LBP
CSLBP	Centre-symmetric LBP
CFS	Correlation-based feature selection
DL	Deep learning
DCNN	Deep convolutional neural network
FC	Fully connected
FP	False positive
FPR	False positive rate
FN	False negative
FS	Feature selection
GAN	Generative adversarial network
GLCM	Gray level co-occurrence matrix
GAP	Global average pooling
HOG	Histogram of oriented gradients
ISIC	International skin imaging collaboration

LBP	Local binary pattern
LBPDAP	Local bit plane-based dissimilarities and adder pattern
LANet	Long attention network
LBDP	Local bit plane decoded pattern
LBDISP	Local bit plane dissimilarity pattern
LBPANDP	Local bit plane adjacent neighborhood dissimilarity pattern
LDEP	Local diagonal extrema pattern
LDP	Local derivative pattern
LDZP	Local directional zigzag pattern
LMeP	Local mesh pattern
LMePVEP	Local mesh peak valley edge pattern
LoG	Laplacian of gaussian
LB-3D-OACSP	Local bit-plane domain 3D oriented arbitrary and circular shaped scanning pattern
LSTM	Long short term memory
LTP	Local ternary pattern
LTCoP	Local ternary co-occurrence pattern
LWP	Local wavelet pattern
LZMHPP	Local zigzag max histograms of pooling pattern
ML	Machine learning
MLP	Multilayer perceptron
MRI	Magnetic resonance imaging
MS-LBASP	Multiscale local bit plane arbitrary shaped pattern
NEMA	National electrical manufacturers association
NSST	Non-subsampled shearlet transform
NSST-LBNDP	NSST local bit-plane neighbour dissimilarity pattern
PCA	Principal component analysis
PET	Positron emission tomography
RGB	Red Green Blue
RTPCR	Real-time reverse transcription-polymerase chain reaction
ResNet	Residual network
ROC	Receiver operating characteristic
SIFT	Scale invariant feature transform
SMOTE	Synthetic minority oversampling technique
SVM	Support vector machine
SURF	Speeded up robust features
SARS-CoV-2	Severe acute respiratory syndrome corona virus 2

SC	Skin cancer
SL	Skin lesion
SS-3D-LTP	Spherical symmetric three-dimensional LTP
SGDM	Stochastic gradient descent with momentum
TBIR	Text based image retrieval
TL	Transfer learning
TP	True positive
TPR	True positive rate
TN	True negative
TCIA	The cancer imaging archive
VGG	Visual geometry group
WHO	World health organization
YOLO	You only look once
3D-LOZFP	Three dimensional local oriented zigzag fused pattern
3D-LTCoP	Three dimensional local ternary co-occurrence pattern
3D-LCDP	Three dimensional local circular difference pattern
3D-LCDWP	Three dimensional local circular difference wavelet pattern
3D-LOZTCoFP	Three dimensional local-oriented zigzag ternary co-occurrence fused pattern

List of Symbols

$I(p, q)$	Image
B_k	Binary bit in k^{th} bit plane
b_d	Bit depth
R	Number of rows
C	Number of columns
t	Neighbour
$\varphi(v)$	Threshold function, equal to 1 if v is greater than or equal to 0, else equal to 0
$E^{p,q,k}$	Local bit-plane encoded value
$MS-LBASP_S^{p,q}$	Sign MSLBASP
$MS-LBASP_M^{p,q}$	Magnitude MSLBASP
Th	Threshold
$MS-LBASP_{S_q}$	Quantized $MS-LBASP_S^{p,q}$
$MS-LBASP_{M_q}$	Quantized $MS-LBASP_M^{p,q}$
Db	Size of dataset
$P(I_j)$	Precision
$R(I_j)$	Recall
F_L	Feature vector length
$D(I_q, Db_k)$	Distance between the query image I_q and the database's k^{th} image
σ_s	Standard deviation ($s \in [1, 2, 3]$)
$G(i, j, \sigma)$	Gaussian filter for standard deviation σ_s
FI_s	Gaussian filtered image
N_R	Number of rows
N_C	Number of columns
m	Unique patterns, $m \in [1, 2, 3]$
b	Bit plane, $b \in [7, 6, 5, 4, 3, 2, 1, 0]$
k	Direction $k \in [0^0, 45^0, 90^0, 135^0]$
AP_k^m	3D arbitrary patterns

CP_k	3D circular patterns
$3DAP_k^{b,m}$	Encoded binary BPs using AP_k^m
$3DCP_k^b$	Encoded binary BPs using CP_k
$3DAFP^{b,m}$	Fused $3DAP_k^{b,m}$ for four different directions
$3DCFP^b$	Fused $3DCP_k^b$ for four different directions
$3DACFP^b$	Combination of all pattern maps
$LB-3D-OACSP(p,q)$	Local Bit-Plane Domain 3D Oriented Arbitrary and Circular Shaped Scanning Patterns
$\psi(x)$	Threshold function, equal to 1 if x is greater than or equal to 0, else equal to 0
$H_{LB-3D-OACSP^{p_x}}(l)$	Histogram of $LB-3D-OACSP$
$f_m(a,b)$	Threshold function, equal to 1 if a=b, else equal to 0
$BI(x,y)$	Image
R_1	Radius 1
R_2	Radius 2
$C_t^k(x,y)$	Dissimilarity between the reference bit and all its neighbouring bits at radius 1
$D_t^k(x,y)$	Dissimilarity between the neighbours at radius 1 and the selected neighbours at radius 2
$\rho(e,f)$	Threshold function, equal to 1 if $e \neq f$, else equal to 0
$\phi(e,f)$	Threshold function, equal to 1 if $e \neq f$, else equal to 0
$DS^k(x,y)$	Dissimilarity between C_t^k and D_t^k
$LBMDP(x,y)$	Local BP multiple dissimilarity pattern
L_{GAN}	Adversarial loss
L_{cyc}	Cycle-consistency loss