

**COMPUTER-AIDED EXTRA-PULMONARY
TUBERCULOSIS DIAGNOSIS USING IMAGE
PROCESSING AND HMLP NETWORK**

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UNIVERSITI MALAYSIA PERLIS

2014

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TUBERCULOSIS DIAGNOSIS USING IMAGE
PROCESSING AND HMLP NETWORK**

by

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A thesis submitted in fulfillment of the requirements for the degree of
Doctor of Philosophy (Biomedical Electronic Engineering)

**School of Mechatronic Engineering
UNIVERSITI MALAYSIA PERLIS**

2014

ACKNOWLEDGEMENT

Alhamdulillah, all praises belongs to Allah, the most merciful, the most beneficent and the most kind for giving me the strengths, courage and opportunity to carry out and complete this thesis.

I am grateful and deeply indebted to my supervisor, Prof. Dr. Mohd Yusoff Mashor, Dean of Centre for Graduate Studies, Universiti Malaysia Perlis (UniMAP). I have the great privilege and honour to express my whole hearted indebtedness to him for his guidance, supervision, inspiring encouragement, constructive criticism and help in carrying out this thesis work. In addition, I would like to express my gratitude to thank my co-supervisor Prof. Dr. Hasnan Jaafar, pathologist of Hospital University Sciences Malaysia for his valuable comments and suggestion on improving my research work.

I would like to express my deepest gratitude to my beloved parents, Abah and Ummy, my wife, Ernie, my children, Hafizi, Huzafah, Hanif and Hasif for sharing my pain and pleasure.

Last but not least, I would like to thank the team members of Electronic & Biomedical Intelligent Systems (EBItS) research group for making the AutoMAV lab an enjoyable place to work, staffs in Department of Pathology HUSM especially to Mrs. Cik Noriah Cik Hak for providing ZN-stained tissue slides and validating experimental results, and everyone that involve in this research.

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LIST OF ABBREVIATIONS

AFB	Acid-fast bacilli
AI	Artificial intelligence
AIDS	Acquired immune deficiency syndrome
ANN	Artificial neural network
ASRG	Automatic seeded region growing
BCG	Bacille Calmette-Guerin
BP	Backpropagation
CL	Confidence level
CT	Computed tomography
CXR	Chest x-ray
DA	Discriminant analysis
DNA	Deoxyribonucleic acid
ELM	Extreme learning machine
EPTB	Extra-pulmonary tuberculosis
FN	False negative
FP	False positive
GB	Gigabyte
GUI	Graphical user interface
HIV	Human immunodeficiency virus
HMLP	Hybrid multilayered perceptron
H ² MLP	Hierarchical hybrid multilayered perceptron
HSI	Hue, saturation, intensity
HUSM	Hospital Universiti Sains Malaysia
IGRA	Interferon Gamma Release Assays

IP	Image processing
kNN	<i>k</i> -Nearest neighbour
LDA	Linear discriminant analysis
LM	Levenberg-Marquardt
LED	Light-emitting-diode
LED-FM	Light-emitting-diode fluorescence microscope
LJ	Lowenstein-Jensen
MELM	Modified Extreme Learning Machine
MDR-TB	Multidrug-resistant tuberculosis
MI	Mutual information
MLP	Multi layer perceptron
MRI	Magnetic resonance imaging
mRMR	Minimal-Redundancy-Maximal-Relevance
MRPE	Modified recursive prediction error
MRPE-MELM	Modified Recursive Prediction Error – Modified Extreme Learning Machine Algorithm
MTB	<i>Mycobacterium tuberculosis</i>
NAAT	Nucleic acid amplification test
NN	Neural network
p-HMLP	Parallel hybrid multilayered perceptron network
PNN	Probabilistic neural network
PPD	Purified protein derivative
PTB	Pulmonary tuberculosis
QDA	Quadratic discriminant analysis
RAM	Random-access memory
RBC	Red blood cell
RBF	Radial basis function

RGB	Red, green, blue
RNA	Ribosomal ribonucleic acid
RLS	Recursive least square
RPE	Recursive prediction error
SLFN	Single-hidden layer feedforward network
SSE	Sum of square error
SVM	Support Vector Machine
TB	Tuberculosis
TN	True negative
TP	True positive
TST	Tuberculin skin test
WHO	World Health Organization
XDR-TB	Extensively drug-resistant tuberculosis
ZN	Ziehl-Neelsen

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LIST OF SYMBOLS

$I_1 - I_6$	Affine moment invariants
$\sigma_{between}^2$	Between-class variance
b	Bias
μ_{pq}	Central moment of order $(p + q)$ of an object
c_l	Centre with the largest fitness
c_s	Centre with the smallest fitness
c_j	Cluster centre
$J(\hat{\Theta})$	Cost function
β_{lm}	Decay rate
d_{svm}	Degree of polynomial kernel
$y_k(t)$	Desired (target) output
D_1	Dispersion
D_2	Dispersion
ε	Eccentricity
E	Ellipticity
\mathbf{e}	Error vector
$\hat{\Theta}$	Estimated parameter vector
d_{ji}	Euclidean distance between x_i and c_j .
$f(c_j)$	Fitness of j -th centre
$\lambda(t)$	Forgetting factor

$\psi(t)$	Gradient of the one-step-ahead predicted output
H	Hidden layer output matrix
$\phi_1 - \phi_7$	Hu's moment invariants
H_{hsi}	Hue of HSI colour model
θ_{c-y}	Hue of C-Y colour model
I	Identity matrix
$f(x, y)$	Image pixel value
$f_{gf}(x, y)$	Image pixel value after applying global fixed thresholding
$f_l(x, y)$	Image pixel value after applying local adaptive thresholding
$f_b(x, y)$	Image pixel value in binary
x	Input signal
I_{hsi}	Intensity of HSI color model
J	Jacobian matrix
$p(x, y)$	Joint probabilistic density for feature x and y
γ_{svm}	Kernel parameter
$\alpha_g(t)$	MRPE learning rate
μ_{lm}	Levenberg-Marquardt learning rate
$T_{n,local}$	Local threshold value
Y_{c-y}	Luminance of C-Y colour model
$p(x)$	Marginal probabilistic density function for feature x
$p(y)$	Marginal probabilistic density function for feature y
A_{max}	Maximum of predefined size

r_{\max}	Maximum radius
γ	Maximum range of an activation function
μ	Mean
μ_{bck}	Mean intensity of the background
μ_{obj}	Mean intensity of the objects
$\bar{x}_{n,local}$	Mean of local intensity distribution of n -th region
μ_{ji}	Membership function
A_{\min}	Minimum of predefined size
r_{\min}	Minimum radius
m_{pq}	Moment of order $(p + q)$ of an object
$\alpha_m(t)$	Momentum
\mathbf{H}^\dagger	Moore-Penrose generalized inverse
$I_{mi}(x, y)$	Mutual information for feature x and y
\hat{y}	Neural network output
η_{pq}	Normalized central moment of order $(p + q)$ of an object
N_{c_j}	Number of pixels belong to centre c_j
BG^+	Number of correctly segmented background pixel
TB^+	Number of correctly segmented TB pixel
N_h	Number of hidden nodes
BG^-	Number of incorrectly segmented background pixel
TB^-	Number of incorrectly segmented TB pixel
N_i	Number of input nodes

N_o	Number of output nodes
n_p	Number of parameters in a HMLP network
J	Objective function
$\hat{y}_k(t)$	Output of the k -th output node at t -th sample of a neural network
$h_j(t)$	Output of the j -th hidden node at t -th sample
P	Perimeter
(x, y)	Pixel location
$e_k(t)$	Prediction error of k -th output node at t -th sample
A	Region size
D	Relevance
S_{hsi}	Saturation of HSI color model
S_{c-y}	Saturation of C-Y color model
Ω_s	Selected feature set with m features
SF	Shape factor
λ	Slope of an activation function
σ_{sf}	Spread factor
σ	Standard deviation
$B - Y$	Subtraction of Y from B component
$G - Y$	Subtraction of Y from G component
$R - Y$	Subtraction of Y from R component
Λ	Symmetric positive definite matrix
T	Threshold value
Ω_t	To-be-selected feature set which consists of m features