Automatic Defect Detection using Enhanced Motif and Non-Motif Algorithms in 2D Patterned Texture Images

By

Anitha. S

Supervisor

Dr. V.Radha

A thesis submitted to

Avinashilingam Institute for Home Science and Higher Education for Women,

Coimbatore – 641043

In partial fulfillment of the requirements for the Degree of

Doctor of Philosophy in Computer Science

October 2013

CERTIFICATE

This is to certify that the thesis entitled **"Automatic Defect Detection using Enhanced Motif and Non-Motif Algorithms in 2D Patterned Texture Images"** submitted to the Avinashilingam University for Women, Coimbatore, for the award of the degree of **Doctor of Philosophy in Computer Science**, is a record of original research work done by **S. Anitha**, during the period of her study in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under my supervision and guidance and the thesis has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship or similar title to any candidate of any University or Institute.

Signature of the Head of the Department 31/10/13

Dr.G.PADMAVATHI
M.Sc., M.Phil., Ph.D.
Professor and Head
Department of Computer Science
Avinashilingam Institute for Home Science
and Higher Education for Women
Coimbatore - 641 043

Signature of the Supervisor

Dr. (Mrs) V. RADHA
Professor, Dept. of Computer Science
Avinashilingam Institute for Home Science
and Higher Education for Women
Coimbatore - 641 014

31/10/13

Signature of the Dean

Dr. A.PARVATHI, M.Sc., Dip.H.Ed., M.Phil., Ph.D.
Dean, Faculty of Science
Professor and Head
Department of Mathematics
Avinashilingam Institute for Home Science
and Higher Education for Women
Coimbatore - 641 043

ii

DECLARATION

I hereby declare that the matter embodied in the thesis entitled **"Automatic Defect Detection using Enhanced Motif and Non-Motif Algorithms in 2D Patterned Texture Images"** is the result of investigations carried out by me in the Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, under the supervision and guidance of **Dr. (Mrs.) V. Radha**, Professor, Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, and it has not been submitted for the award of any Degree / Diploma / Associateship / Fellowship or similar title to any University or Institute.

Signature of the Supervisor

Dr. (Mrs) V. RADHA
Professor, Dept. of Computer Science
Avinashilingam Institute for Home Science
and Higher Education for Women
Coimbatore - 641 014

Signature of the Candidate

iii

ACKNOWLEDGEMENT

The investigator, records her sincere thanks to ***Thiru Dr. T.S.K. MEENAKSHI SUNDARAM, M.A., M.Phil.,Ph.D.*** *Chancellor, Avinashilingam Deemed University for Women, Coimbatore, for providing the infra structural facilities for the conduct of the study.*

The investigator extends her immense gratitude to ***Dr.(Mrs.) SHEELA RAMACHANDRAN****, M.Sc., P.G. Dip., Ph.D. Vice Chancellor, Avinashilingam Deemed University for Women, Coimbatore, for her constant encouragement and support for the completion of the study.*

The investigator expresses her special thanks to ***Dr. GOWRI RAMAKRISHNAN****, M.Sc., M.Phil., Ph.D. Registrar, Avinashilingam Deemed University for Women, Coimbatore for extending her precious help.*

The investigator records her gratefulness to ***Dr.(Mrs.) A.PARVATHI,*** *M.Sc., Dip. Ed.,M.Phil., Ph.D., Dean, Faculty of Science, Professor and Head, Department of Mathematics, Avinashilingam Deemed University for Women, Coimbatore for her timely help and encouragement in carrying out the research work.*

Heartfelt thanks are expressed to ***Dr.(Mrs) G.PADMAVATHI****, M.Sc., M.Phil., Ph.D. Professor and Head of the Department of Computer Science, Avinashilingam Deemed University for Women, Coimbatore, for her constant encouragement,concern and willing help rendered during the course of the study.*

With glowing sense of gratitude and honesty, the researcher places her sincere and grateful thanks to her most honoured guide ***Dr.(Mrs) V.RADHA,*** *M.Sc., P.G.D.C.A., P.G.D.O.R., B.Ed., M.Phil., Ph.D. Professor, Department of Computer Science, Avinashilingam Deemed University for Women, Coimbatore, for her dynamic guidance, scholarly advice, affable help, constructive criticism, constant encouragement, patience and dedication, without which the conduct of the study would have been impossible.*

*The investigator expresses her sincere thanks to the beloved **TEACHERS**, Department of Computer Science, Avinashilingam Deemed University for Women, Coimbatore for their advice and support.*

*The investigator also expresses her warm gratitude to all her **FRIENDS** for their valuable help and suggestions rendered throughout the tenure of the research work.*

*Finally, on a personal note, the investigator owe her respected and very special thanks to her **FAMILY MEMBERS** for their unending love and unconditional support, without whose help, co-operation and encouragement, this research would not be successful.*

*Above all, the investigator raises her humble heart in adoration to **GOD ALMIGHTY,** who in His infinite goodness and wisdom has designed and executed the research.*

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
ANFIS	Adaptive Neural Fuzzy Interface System
ANN	Artificial Neural Network
AR	Autoregressive
BB	Bollinger Bands
BPNN	Back Propagation Neural Network
CCD	Charge Coupled Device
Cdf	Cumulative Distribution Function
CM	Co-Occurrence Matrix
DCT	Discrete Cosine Transform
DFE	Discriminative Feature Extraction
DHT	Discrete Hadamard Transform
DOC	Deviation Of The Contrast
DST	Discrete Sine Transform
DT	Direct Thresholding
DWT	Discrete Wavelet Transformation
EDR	Ellipsoidal Decision Region
EDSMF	Enhanced Directional Switching Median Filter
EDSMF	Enhanced Directional Switching Median Filter
EMBMAS	Enhanced Motif Based Method with Autocorrelation and Spatial Information
EMBMAS	Enhanced Motif-Based Defect Detection System With Autocorrelation and Spatial Information
ESDMF	Enhanced Switching Directional Median Filter
EV	Energy and Variance
FCM	Fuzzy C-Means
FDMLE	Fourier-Domain Maximum Likelihood Estimator
FIR	Finite Impulse Response
FM	Fuzzy Modeling

ABBREVIATIONS	DESCRIPTION
FT	Fourier Transform
GA	Genetic Algorithm
GA	Genetic Algorithm
GGI	Gabor Wavelets Based GIS Algorithm Using ICA Projections
GGVP	Gabor Wavelets Based GIS Algorithm Using VQ + PCA Projections
GGVPI	Gabor Wavelets Based GIS Algorithm Using VQ + PCA + ICA Projections
GIN	Gabor Wavelets Based Using ICA Projections on Neural Network
GIS	Golden Image Subtraction
GISDT	Golden Image Subtraction Combined With Direct Thresholding
GLCM	Gray Level Co-Occurrence Matrix
GLCM	Gray Level Co-Occurrence Matrix
GLD	Gray Level Difference Method
GLDM	Gray Level Dependence Matrix
GMRF	Gaussian Markov Radom Field
GT	Gabor Transform
GT	Gabor Transform
GVP	Gabor Wavelets Using VQ + PCA Projections on Neural Network
GVPIN	Gabor Wavelets Based Using VQ + PCA + ICA Projections On Neural Network
GWN	Gabor Wavelet Network
ICA	Independent Component Analysis
IDF	Image Data Fusion
IS	Intensity Strength
KL	Karhunen–Loeve
KLT	Karhunen-Loeve Transform
KSOFM	Kohonen Self Organizing Feature Map

ABBREVIATIONS	DESCRIPTION
LED	Light-Emitting Diode
LNE	Large Number Emphasis
MBM	Motif Based Method
MFD	Maximum Frequency Difference
MLP	Multilayer Perceptron
MMDR	Max–Min Decision Region
MRF	Markov Random Field
MSDF	Multi-Scale Differentiation Filtering
MSSI	Mean Structural Similarity Index
ND	Noise Density
NF	Number of Noise Free Pixels
NMBM	Non-Motif Based Methods
NN	Neural Network
NN	Number of Noisy Pixels
OGI	Optimal Wavelet Tree Based GIS Algorithm Using Ica Projections
OGVP	Optimal Wavelet Tree Based GIS Algorithm Using VQ + PCA Projections
OGVPI	Optimal Wavelet Tree Based GIS Algorithm Using VQ + PCA + ICA Projections
OIN	Optimal Wavelet Tree Based Using Ica Projections on Neural Network
OVPIN	Optimal Wavelet Tree Based Using VQ+ PCA + ICA Projections On Neural Network
OVPN	Optimal Wavelet Tree Using VQ + PCA Projections on Neural Network
PC	Principal Component
PCA	Principal Component Analysis
PCA	Principal Component Analysis
PCB	Printed Circuit Board
PCNN	Pulse-Coupled Neural Network

ABBREVIATIONS	DESCRIPTION
Pdf	Probability Density Function
PGF	Peer Group Filters
PSNR	Peak Signal To Noise Ratio
RA	Regularity Analysis
RB	Regular Bands
RBF	Radial Basis Function
SA	Structural Approach
SAD	Sum of Angular Distance
SBCM	Sub-Band Co-Occurrence Matrix
SGLDM	Spatial Gray Level Dependence Matrix
SID	Sum of Intensity Distance
SM	Stochastic Modeling
SMF	Switching Median Filter
SOFM	Self-Organizing Feature Map
SQ	Scalar Quantization
SSD	Sum Of Squared Difference
SVM	Support Vector Machines
TIS	Traditional Image Subtraction
VMF	Vector Median Filter
VQ	Vector Quantization
W	Wavelet Transform
WGIS	Wavelet Preprocesses Golden Image Subtraction
WGIS	Wavelet and GIS Algorithm

ABSTRACT

Defect detection of patterned fabric is a challenging problem in automatic inspection and is heavily used by the textile and garment manufacturing industries worldwide. It is an important task of quality control which helps to reduce rejection of fabrics and time spent on manual inspection. Over the past few years, many automatic computer aided defect detection systems that can detect defects from fabric images have been developed. Many of these systems are designed for non-patterned plain fabrics. However, the heavy use of patterns in the 21st century fashion world, defect detection in patterned fabrics has become more vital. This research work designs and develops defect detection systems for patterned fabrics.

The proposed research methodology consists of three phases. The first step focuses on fabric image enhancement techniques. In this step, an input fabric image is enhanced by removing the impulse noise. For this purpose, an enhanced directional switching median filter is proposed.

The second and third phase of the study focuses on the design and development of defect detection algorithms that identifies and locates defects in 2D patterned fabric images. The study considered both non-motif (Phase II) and motif (Phase III) based algorithms. In Phase II, the first technique proposed uses image data fusion technology which combines edge information obtained from Sobel edge operator, wave profiles and seam lines along with a dynamic threshold for defect detection. In the same phase, 12 wavelet-based techniques are also proposed. For this purpose, two wavelet variants, namely, optimal wavelet tree and Gabor wavelets are used. Optimal coefficients from these variants are selected using three algorithms. The first selection algorithm uses Vector Quantization and Principal Component Analysis, the second method uses Independent Component Analysis and the third performs a multiple projection-based selection combining the first two techniques. For defect detection, a golden image subtraction with direct thresholding method and a multilayer perceptron neural network based method are used.

In the third Phase, method for non-motif defect detection is explored. The enhanced motif-based algorithm, after histogram equalization, the algorithm detects and extracts lattices and motifs automatically. The circular shift matrices are constructed by considering spatial relationship. Using this the Energy-Variance plots are built, from which defective and defect-free fabrics are identified

To evaluate the performance of the proposed preprocessing and defect detection algorithms, 600 fabric images were used. The performance evaluation of the preprocessing algorithm was based on four metrics, namely, Peak Signal to Noise Ratio, Figure of Merit, Mean Structural Similarity Index and Speed of enhancement. Similarly, the defect detection algorithms (both motif and non-motif) were evaluated using another set of four parameters, namely, sensitivity, specificity, detection accuracy and speed of defect detection. Five types of defects namely, broken end, hole, netting multiple, thick bar and thin bar defects were considered.

The experimental results showed that the performance of all the proposed models increased when compared with the existing algorithms. Among the proposed non-motif models, the model that combined Gabor wavelets with multiple projection selection algorithm and multilayer perceptron produced improved results. The inclusion of the enhancement operations in motif-based algorithm produced positive results in terms of sensitivity, specificity, detection accuracy and speed of detection. Comparison of motif and non-motif based algorithms, revealed that motif based algorithm produce better results.

Experimental results prove that the proposed models are efficient with small time complexity and can therefore be used by the textile industries to identify defects and increase customer satisfaction.