Faculty of Engineering
Mechatronics Engineering Department

Design and Development of Automatic Visual Inspection System for Manufacturing

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

MECHANICAL ENGINEERING
(MECHATRONICS)

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Statement

This thesis is submitted in the partial fulfillment of master degree in Mechanical Engineering in Ain-Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

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Acknowledgement

قال تعالى : " وَاشْكُرُوا لِلَّهِ إِن كُنتُمْ إِيَّاهُ تَعْبُدُونَ"

[سورة البقرة :172]

اللهم لك الحمد حتى ترضى ولك الحمد إذا رضيت ولك الحمد بعد الرضا حمدا كما ينبغى لجلال وجهك وعظيم سلطانك

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Abstract

This study is paying special attention to Printed Circuit Boards (PCBs) manufacturing as one of the most important applications for Automatic Visual Inspection (AVI). It provides fast modified procedure to detect the components and the solder-joints of PCBs. In the Automatic Optical Inspection (AOI), one of the AVI approaches, the principal challenges in PCB analysis lie in the high reflectance of the surface, the un-even illumination, the specular nature of the solder joints, and the potential complexity of the background.

For industrial application, the feasibility and reliability form two major factors to keep the marketing competition. In case of the PCB, the minimization and the advancing in the PCB manufacturing multiplies the time-consuming for inspection.

The suggested methodology employs the Discrete Cosine Transform (DCT) to enhance the desired feature cohesion. Furthermore, the color disturbance is involved to illustrate the components. Finally, the detection has been done by employing a multi-stage segmentation. The classifier is designed to detect five different classes depicts the soldering conditions: good, missing, no-solder, exceed and bridged. The features of four different classes are extracted using a time-frequency localization wavelet.

The experiment expresses good results supported by the near optimality of the Log-Gabor filter bank. This allows the image to convolve with a Gabor atoms in the logarithmic prospective, whereas a zero DC component. The obtained results were undergone upon a fast time implemented algorithm in order to meet the flexibility conditions.

Summary of the M.Sc. Thesis

“Design and Development of Automatic Visual Inspection System for Manufacturing”

This piece of research has discussed a methodology for extracting solder joints from PCBs effectively under different illumination conditions and background disturbance in machine vision field.

Chapter one provides an introduction to the topic. . In more details, the main challenges, the previous solutions for the PCB inspection problems and the accumulation of errors are discussed. The chapter illustrates the preliminaries of the suggested system as well.

Chapter two introduces the design phase of the complete Mechatronic system for the automated optical inspection of the PCB systems and the proposed algorithm.

In Chapter three the experimental setup is illustrated to measure the efficiency of the proposed methodology in addition to a complete definition for each of the subsystems and the component of the system. During this chapter the designed Graphical User Interface (GUI), which has been built-in by the suggested system, is discussed.

In Chapter four the experiments conducted are presented in order to examine the efficiency of the proposed system and implemented algorithms. Based on the above mentioned work, some recommendations and future research are introduced in Chapter five.

Nomenclature

List of Symbols and Notations

α	The DCT coefficients
s_c	Number of Log-Gabor filters bank scales
o_r	Number of Log-Gabor filters bank orientations
ρ, ρ_{s_c}	Radial components of the log-polar coordinates
θ, θ_{s_c,o_r}	Angular components of the log-polar coordinates
$\sigma_{\rho,}, \sigma_\theta$	Bandwidth of log-polar coordinates
β	Log-Gabor filter bandwidth
κ_β	Gaussian low-pass filter standard deviation
R, G, B	The channels of the RGB color space
Y, C_b, C_r	The channels of the YC_bC_r color space
L, a, b	The component of the CIEL*a*b color space
Sb, Sa	Designed salient components of the CIEL*a*b color space
S_{ROI}	ROI salient layer
ω_0, ω_1	Accumulative sums of the probabilities of bi-level threshold
$\mu_0, \mu_{1,}, \mu_T$	Mean intensities of the probabilities of bi-level threshold
$O_{s,t}$	Optimal threshold for bi-level
C_k	DCT frequency center
$F_{variance}$	DCT Average frequency variance
A_h	DCT hidebound area
A_n	DCT selected area
C_n	DCT center of the selected area
F_R	DCT Frequency variance ratio

F_n	DCT frequency total variance
Y_{SJ}, B_{SJ}, H_{SJ}	The blue/yellow stimulus salient layer components
Y_{adj}	Adjusted luminance layer
Y_{comp}	The compensated and scaled luminance layer
m_{bg}	Background average intensity value
S_{SJ}	Salient solder-joints layer
R_m, G_m, B_m	The modified channels of the RGB color space
D_{mahal}	Mahalanobis distance

List of Acronyms

AOI	Automated Optical Inspection
AVI	Automated Visual Inspection
ANN	Artificial Neural Network
CCD	Charge Coupled Device
CFA	Color Filter Array
CIELab or CIEL*a*b	Comission Internationale de l'Eclairage
CV	Computer Vision
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
DIP	Digital Image Processing
EXIF	Exchangeable Image File Format For Digital Still Cameras
FBT	Functional Baseline Test
FDA	Fisher Discriminant Analysis
FT	Fourier Transform
FFT	Fast Fourier Transform
FLA	Fisher Linear Analysis
GIF	Graphic Interchange Format
HT	Hough Transform
IDCT	Inverse Discrete Cosine Transform
IDFT	Inverse Discrete Fourier Transform
IFT	Inverse Fourier Transform
LVQ	Learning Vector Quantization

LDA	Linear Discriminant Analysis
JPEG	Joint Photographic Experts Group
MV	Machine Vision
PCA	Principal Component Analysis
PCB	Printed Circuit Board
PNG	Portable Network Graphics
RGB	Red, Green and Blue Color Model
RIF	Raster Image Format
SCARA	Selective Compliant Articulated Robot for Assembly
TIFF	Tagged Image File Format
XYZ	The three stimulus of the color model

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