UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AUTOMATED VISION-BASED BEVERAGE BOTTLE QUALITY AND LEVEL INSPECTION SYSTEM

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MASTER OF SCIENCE IN ELECTRONIC ENGINEERING

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Faculty of Electronic and Computer Engineering

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A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
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DECLARATION

I declare that this thesis entitled "Automated Vision-Based Beverage Bottle Quality and Level Inspection System" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of the Master of Science in Electronic Engineering.

Signature : ……………………………………....

Supervisor Name : Dr. Norhashimah Binti Mohd Saad

Date : ……………………………………

DEDICATION

A million praise towards my family, my respectful supervisor, examiner and lecturers and to all my friends for their support and cooperation in helping me to complete this thesis.

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ABSTRACT

Automated vision inspection emerged as an important part of the product quality monitoring process. It is a requirement of International Organization for Standardization (ISO) 9001 to appease the customer satisfaction in terms of frequent improvement of the quality of products. It is totally impractical to rely on human inspector to handle a large scale quality control production because human has major drawback in their performance such as inconsistency and time consuming. Therefore, an automatic inspection is a promising approach to maintain product quality as well as to resolve the existing problems relate to delay outputs and cost burden. This research presents a computerized analysis to detect defects occur in beverages production in order to minimize the defective products. Image processing techniques are proposed to detect defects of beverages bottle. The defects are categorized into three classes which are bottle shape defect, color concentration defect and liquid level defect. For shape defect detection, three techniques are proposed namely local standard deviation (LSD), morphological operation and adaptive thresholding. Statistical histogram, gray level co-occurrence matrix (GLCM) and quadratic distance are applied for color concentration defect detection. The liquid level is detected using Hough transform and coordinate of point techniques. The classification process is analyzed using rule-based and decision tree classifiers. In developing automated beverage bottle quality and level inspection system, the performance is verified in terms of accuracy. The simulation result demonstrate LSD, statistical histogram and Hough transform are selected as the best technique by achieving 98% of shape, 93% of color concentration and 91% of liquid level. For the system result, 93% average accuracy has achieved for three defect detections. The system is ready for internet of things (IoT) platform which is using raspberry pi that gives benefit to user for wirelessly access and monitor the results. For the results validation, field testing is conducted, and the proposed system shows the capability to classify the bottle defect accurately. Thus, it has proven the proposed system is appropriate to be implemented in real-time application for beverage bottle quality inspection.

ABSTRAK

Pemeriksaan penglihatan automatik telah muncul sebagai bahagian penting dalam proses pemantauan kualiti produk. Ia adalah keperluan Pertubuhan Pemiawaian Antarabangsa 9001 bagi memenuhi kepuasan pelanggan dari segi kekerapan peningkatan kualiti produk. Adalah tidak praktikal untuk bergantung kepada pemeriksa manusia bagi mengendalikan pengeluaran kawalan dalam kualiti yang berskala besar kerana manusia mempunyai kelemahan utama dalam prestasi mereka seperti tidak konsisten dan mengambil masa yang sangat lama. Oleh itu, pemeriksaan automatik adalah pendekatan yang menjanjikan dapat mengekalkan kualiti produk serta menyelesaikan masalah yang ada berkaitan dengan kelewatan pengeluaran dan beban harga. Penyelidikan ini membentangkan analisis berkomputer untuk mengesan kecacatan berlaku dalam pengeluaran minuman untuk meminimumkan produk yang cacat. Teknik pemprosesan imej dicadangkan untuk mengesan kecacatan botol minuman. Kecacatan ini dikategorikan kepada tiga kelas iaitu kecacatan bentuk botol, kecacatan kepekatan warna dan kecacatan paras cecair. Untuk mengesan kecacatan pada bentuk, tiga teknik dicadangkan iaitu sisihan piawai tempatan, operasi morfologi dan ambang adaptif. Statistik histogram, matrik gray level co-occurrence (GLCM) dan jarak kuadratik digunakan untuk mengesan kecacatan kepekatan warna. Paras cecair dikesan menggunakan jelmaan Hough dan titik koordinat. Proses klasifikasi dianalisis dengan menggunakan asas aturan dan akar pokok keputusan. Dalam membangunkan sistem pemeriksaan kualiti botol minuman dan aras berasaskan penglihatan automatik, teknik terbaik telah dipilih dari segi ketepatan. Hasil ketepatan simulasi menunjukkan sisihan piawai tempatan, statistik histogram dan jelmaan Hough dipilih sebagai teknik terbaik dengan mencapai 98% bentuk, 93% kepekatan warna dan 91% paras cecair. Bagi keputusan sistem, ketepatan purata 93% telah dicapai bagi ketiga-tiga pengesanan kecacatan. Sistem ini telah bersedia untuk penggunaan platform internet of things dengan menggunakan raspberry pi yang akan memberikan manfaat kepada pengguna untuk mengakses dan mengawasi keputusan tanpa wayar. Untuk pengesahan keputusan, ujian lapangan dijalankan, dan sistem yang dicadangkan menunjukkan keupayaan untuk mengklasifikasikan kecacatan botol dengan tepat. Oleh itu, ia telah membuktikan sistem yang dicadangkan sesuai untuk dilaksanakan dalam permohonan masa nyata bagi pemeriksaan kualiti produk. Penyelidikan ini akan menyokong IKS dalam membangunkan teknologi automatik canggih yang sejajar dengan revolusi perindustrian keempat.

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2D	-	2-Dimensional
ACE	-	Adaptive Contrast Enhancement
ACM	-	Active Counter Model
ADSP Lab	-	Advanced Digital Signal Processing Laboratory
DWI	-	Diffusion-Weighted Imaging
FCM	-	Fuzzy C-means
FN	-	False Negative
FP	-	False Positive
FPGA	-	Field Programmable Gate Array
GLCM	-	Gray Level Co-Occurrence Matrix
GUI	-	Graphical User Interface
HD	-	High Definition
HSV	-	Hue Saturation Value
IoT	-	Internet of Thing
IP	-	Internet Protocol
ISEF	-	Infinite Symmetrical Edge Filter
ISO	-	International Organization for Standardization
LED	-	Light Emitting Diode
LSD	-	Local Standard Deviation
MLP	-	Multilayer Perceptron
NN	-	Neural Network
PC	-	Personal Computer
RBPNN	-	Radial Basis Probabilistic Neural Network
RGB	-	Red Green Blue
ROI	-	Region of Interest
SHFCM	-	Statistical Histogram based Fuzzy C-means

SME	-	Small and Medium Enterprise
SVM	-	Support Vector Machine
T	-	Threshold
TN	-	True Negative
TP	-	True Positive
UTeM	-	Universiti Teknikal Malaysia Melaka
VS	-	Visual Studio