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Soldering defect inspection system using image processing.

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ABSTRACT

Soldering is one of the metal joining process has great impact in manufacturing the electrical and electronic components. Identifying the solder joint defects is one of the tedious processes in order to minimize the production cost, to improve the quality of the metal joint and also to enhance the strength of the material. Defect identification methods are very challenging in all engineering industry. Without machining, the major defects can be identified by visual inspection method but it proved incapable in case of finding fine defects. In this research, a new non destructive method is proposed to inspect the defects that occur after soldering.

Keywords: Soldering, Image processing, Defect inspection, Welding Defect.

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INTRODUCTION

The Metal joining process had a great impact in modern manufacturing technology in improving the performance and reliability of many engineering products that are used in our day to day life. Soldering is one of the process in which two or more metal items are joined together by melting and flowing a filler metal (solder) into the joint, the protective material metal having a lower melting point than the adjoining metal. Soldering is one of the metal joining process has great impact in manufacturing the electrical and electronic components. Identifying the solder joint defects is one of the tedious processes in order to minimize the production cost, to improve the quality of the metal joint and also to enhance the strength of the material. This technology has increased the life, performance and reliability of many electronic components. In the present research, a new method to find the surface defects in soldered region by image analysis process using machine vision. Image analysis involves the conversion of features and objects in image data into quantitative information about these measured features and attributes.

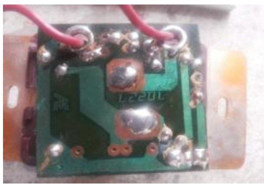

Figure 1: Sampled Image

Machine vision (MV) is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control. It is the analysis of images to extract data for controlling a process or activity. Today, some fields such as medical, astronomy, forensics, defense, remote sensing, and manufacturing rely upon imagery to accumulate, present, and provide in sequence about the world. The challenge faced by scientists, engineers and business people is to quickly extract valuable information from raw image data. This is the most important purpose of image processing is converting images to information. Image analysis involves the conversion of features and objects in image data into quantitative information about these measured features and attributes. Techniques used in MV image processing include: thresholding (converting a grayscale image to black and white or using separation based on a grayscale value), segmentation, pattern recognition, and data matrix code reading, optical character recognition, gauging (measuring object dimensions), positioning, edge detection, filtering (e.g. morphological filtering) and template matching (finding, matching, and/or counting specific patterns). After registration on the microscope the digital images are loaded to image processing software for further processing. The data includes information about pseudo color, pixel dimensions, time scale etc. First image data get adjusted by background subtraction, contrast enhancement, etc. Colors might be assigned; sub volumes selected; z-mismatches corrected by pixel-shifts. The software offers analytical tools for measurement and quantification: automated counting of features, measurements of areas and volumes, tracing of filaments, measuring of distances, evaluation of co-localization, etc,. And finally the parameters like mean, standard deviation, area, homogeneity, correlation, etc, has been calculated for the brightest segmented image and kept as reference values to compare with the values of these parameters of other segmented images. This comparison will evaluate the soldered surfaces.

On surveying the previous literature relevant to Image Processing technique and Soldering defect inspection methods, it was revealed that application of Image processing in Soldering defect analysis would bring greater benefits in terms of simplification of inspection system, reduction of cost and time. Here the following are some summary of previous work done in inspection system of machining tools in verifying parameters like surface roughness, tool wear, coating thickness, etc, and also in welding inspection system, this technique proved to be very effective.

Soldering performance

I have seen lot's of advice given to people on soldering electronic apparatus, some of it fine, some not so fine. I have seen people use all sorts of refuse and claim it does the job, $2 soldering restraints and other passionate objects. Yeah you can melt connect with it, and you can perhaps get a a small amount of tolerable

links occasionally. But if you want to do it the accurate system, consistently, without fighting the iron, and get professional results, read on.
If the instructions given in this article are following with awareness, even someone original to soldering should be quite competent with a few minutes practice; it's really not complex at all. If you don't wish for to take the time to read all the details, I have locate the major points in intrepid at the last part of each sections.

- Surface Roughness
- Tool Wear Measurement
- Tool Profile Geometry Measurement
- Coating Thickness
- Surface Defect Inspection of Cutting Tool
- Measurement of Tool Life
- Welding Defect Detection

Surface Roughness

The measurement in engineering surface roughness is very much important particularly in the case of mechanical surfaces. A quantitative parameter called the optical surface roughness parameter Ga is used to estimate the surface roughness of the machined surface and to test the quantification parameters evaluated using this new system [1]. Measurement of surface roughness parameter 'Ga' optically from an image and conventional average surface roughness 'Ra' obtained from the stylus instrument measured on surfaces are compared. It was observed that the optical surface roughness parameter Ga was in good correlation with the stylus Ra values [1]. The Machine vision approach can be used to evaluate the surface roughness of machined surfaces and there is a good linear relationship between Ra and Ga with a high level of accuracy. Hence the image processing technique can be substituted for conventional measuring system to reduce inspection time and manual errors.

Tool Wear Measurement

Tool wear measurement is of great concern in machining industries for maintaining the surface qualities, précised dimensional accuracy and cost of production of the machined components. Several techniques have been developed for monitoring of wear state, which are cumbersome, time consuming, limited in accuracy and application when they are implemented off-line. The application of image analysis (vision systems) has proved to be very efficient for area detection and technique is readily available for making the 3-D tool wear measurement [7]. It has the capability of making accurate measurement of sizes as small as 50 microns. This technique has the ability to make 3-D tool wear measurement that uses integrating machine vision, image processing and micro-CMM. In this technique, a sequence of images is obtained by continuously on varying the distance between the cutting tool surface and the image detector. Tool wear images were captured and ten different wear description: time-span, size, region, corresponding diameter, centroid, foremost axis duration, unimportant alignment length, solidity, unconventional behaviour and direction were extracted from the images [2, 7]. To enhance the good quality of the image, a self developed shadow removing algorithm written in MATLAB and the Canny edge detection algorithm in digital image processing toolbox for MATLAB was used for the segmentation of the wear area in the captured image. The degree of tool wear was estimated by extracting three parameters viz., intensity histogram, image frequency domain content and spatial domain surface texture. This system can also develop a wear index which represents tool wear condition, a control model for the machined surface, a tool life model for extended use of worn out tool and an optimal control strategy to minimize production cost in machining operation. The tool wear images of the cutters are captured and processed using a machine vision system incorporating with the vertex detection and Visual Inspection technique [8]. The research of vertex detection techniques have been developed in recent years in which high curvature points are commonly called vertices [6]. Vertices play an important role in object recognition.

A. Tool Profile Geometry Measurement

Image processing technique provides a simplified system for measuring geometric profiles of end mills. Digital image acquisition system used to capture images of cutting tools, two linear scales were mounted on the X-Y table for positioning and measuring purposes [3]. Hence, a well-known tool measuring and inspection machine was employed for the measuring standard which compares the difference of the measuring results by using the machine and the proposed system. The percentage of measuring error is acceptable for some geometric parameters of the square or ball nose end mills. The linear scale measurement mode has higher accuracy than the image pixel measurement mode. The advantages of the proposed system are low-priced and efficiency. Furthermore, the designed measuring instrument may be applied to measure geometric profiles of different cutting tools. Therefore, the results demonstrate the effectiveness of the presented approach [3]. The grinding for cutting edges of tools is known as the most important and the final manufacturing procedure which determines geometrical shapes, cutting performance, wear on cutting edges, and tool life. If tool measuring and inspection machines can accurately measure the geometric profiles, this leads to quality improvement of tools for cutting tool manufacturers. In order to match up to the tool precision requirements, the digital image processing technology is widely adopted for measuring the micro-size of work pieces in industries. Because of its practical applicability, much research has been done concerning the tool measurements via the digital image processing. Also a stereometric imaging method was proposed to measure the depth of profile and employed artificial neural network for tool wear estimation. A reliable scheme for the reduction of error components was suggested by using a CCD camera and an exclusive jig to be able to precisely measure the size of tool wear [3]. It also provides the tool wear or the flank wear measuring techniques based on the machine vision system. Silhouette image processing, a simple inspection system for drill point geometry, can measure five geometric parameters and is more precise than human operators with a microscope [3]. The present method is easy to apply and useful due to its simplicity.

Coating Thickness

Image processing aims to develop a characterization method for coating structure based on image analysis for the rational design of coated particles in the pharmaceutical industry [4]. The method applies the MATLAB image processing toolbox to images of coated particles [4]. The coating thicknesses have been determined from statistical analysis that could be performed to obtain relevant thickness properties namely minimum coating thickness and span of the thickness distribution. The application of quantitative image analysis is common practice in fields like the metal industry to detect mechanical defect of products during processing. The quantification method was performed on images acquired using confocal scanning laser microscopy (CSLM) [4]. The quantification comprised the determination of the coating thickness distribution and the pore size distribution. It assesses the effect of the coating process variations on coating quality which plays an important role in determining the final `the influence of different process conditions on coating properties. Further work is ongoing to develop a correlation between the process settings and the covering merits, from which the coating classification results can be proposed to be used as a feedback to control the coating process to assure a coating product with the desired quality.

Before the images were ready to be used for the thickness analysis, several steps had to be performed which comprises image contrast enhancement and image binarization. The contrast enhancement was performed using Contrast-Limited Adaptive Histogram Equalization (ADAPHISTEQ) command in the MATLAB image processing toolbox [9]. There are three algorithms that could be used to determine the coating thickness distribution, the “Radius” method and two variations of the “Euclidean enlarge” presentation. In primary routine, the depth trying started by determining the centre of the particle called as centroid and the inside boundary (facing the core) and the outside boundary (facing the background) of the coating layer. The centroid was determined using the REGIONPROPS command, while the coating boundaries were determined using the BWBOUNDARIES command provided in the MATLAB image processing toolbox [9]. The number of the inside and outside boundary pixels varies slightly depending on the particle and varnish unevenness. The centroid and each of the indoor margin points were then connected with without delay position. This was frequent for all external border pixels. The length of the line segments connecting the centroid-outside boundary and the centroid-inside boundary that run in the same direction are subtracted from each other. The results were taken as the coating thickness [4, 9]. In this way, the variation of the coating thickness along the particle circumference was measured. From the thickness measurements, a coating thickness distribution and a cumulative thickness distribution per particle was obtained and forms the basis for a statistical analysis.

Surface Defect Inspection of Cutting Tool

In manufacturing of cutting tools, failure in coating process and contact with something after coating may occur and results in the spot of the coating. Coating defect tends to occur on periphery of the cutting tools and could be observed as white or black spot compared with its surroundings [5]. It is needed to assure a finished cutting tool with no minute defect on the surface and usually expert skills for visual inspection are employed for inspection. An image processing method and a system for inspection support of a rod figured cutting tool has been developed [5]. The visual inspection of a cutting tool by image processing is not easy as cutting blade have a helical blade structure. As it is the excessive load for human expert, human support inspecting technologies are required. To cope with the problem, an experimental facility with rotation and longitudinal tool shift functions to enable acquisition of blade surface pictures along a cutting rod has been developed. The pre-processing of images is done by system using edge detection and DFT [1, 5]. Conventional detection methods need special processing to extract the striking feature of the defect to match the defect and it is difficult, because the shadow and the curve of the object affect accuracy of the inspection. The cutting tool can be set up by inserting it in the hole. The pulse is transmitted from the computer to the drive motor which controls the cutting tool position in the vertical direction and also in the rotating direction [3]. Further, the camera moved back and forth to change focus. The fluorescent lamp is set up in the apparatus, because fluorescent lamp can cast high diffusible light. The place where a reflected light from the Lev board hit is used for the inspection [5]. As a result, light uniformly lies on the cutting tools. A picture of the entire tool for the inspection is taken. As the result, it becomes possible to inspect it without being obstructed by the reflection of the light source.

Measurement of Tool Life

Tool replacement operations have a great influence over the cost of machined parts. Tool life is the period of time the tool is able to produce in-tolerance parts with regard to dimensions, geometry and roughness. A new procedure that uses a computer vision system to improve the decision about the time for tool replacement and wear level in cutting inserts has been discussed here. The use of contour signatures of the wear region as the input could be implemented [6]. The signature consists of a vector in which each element contains the distance from the centroid of the region to the pixels. The signature is generated using the binary image of the wear region. The cost of tool replacement comprises the cost of tool inserts and costs associated with non-productive periods due to the tool replacement. At present, the common criteria used to determine the time for tool replacement lead to the use of tool inserts only for a fraction of their possible useful life, both in manual and automatic operations. The previous tool replacement criteria do not optimize the use of tools that leads to economic losses. The main drawback of these methods is poor precision and reliability of the measurements, mainly due to the presence of noise in acquired signals. Direct methods are more reliable and offer higher accuracy of the measurements. Application of computer vision technology based on the analysis of digital images in monitoring of cutting tools offers interesting possibilities to determine whether or not the tool wear is underneath the limit of use.

Welding Defect Detection

A methodology that produces a flaw map to plot and obtain the welding defect is devised. The flaw map with adjustment of contrast and brightness level is used to segregate the defects from the welding regions. Since the intensity level of defects in the radiographic images are lower than the neighboring regions, therefore, troughs which can be used to characterize the defect are plotted in the flaw map. A set of rules is applied to detect the flaws.

For further work, a comprehensive test on various welding defects is necessary in order to ascertain its usefulness and effectiveness in defect detection and classification. On the other hand, feature extraction can also be investigated to identify the correct defect from the remaining welding flaws.

Proposed Method

The picture from the camera is imported to a computer through machine vision system. Using image processing techniques in MAT lab R2010a software, the picture is a digitized into a rectangular array element called "pixel" corresponds to the mean intensity in a small rectangular area of original picture. These values are referred as the gray levels of corresponding pixels. Each pixel corresponds to a gray intensity level.

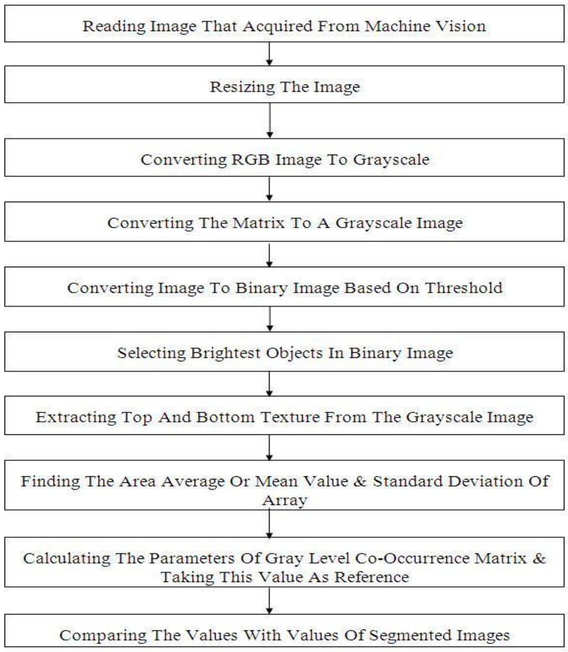

Figure 2: Processing Flow

Modifying the Image View

Transforming, translating, turning and resizing images are common tasks used to focus the viewer's attention on a specific area of the image.

Adding Dimensionality to Image Data

A quantity of images provides additional in sequence while they are placed on a polygon, surface, or geometric shape such as a sphere.

Working with Masks and Calculating Statistics

Image processing uses some fundamental mathematical methods to alter arrays, the form in which the pixels of image are stored. This process includes masking, clipping, locating and statistics.

Warping Images

Data acquisition methods can introduce an unwanted curvature into the image. Image warping uses control points to realign an image along a regular grid or align two images captured from different perspectives.

Specifying Regions of Interest (ROIs)

When processing an image, may want to concentrate on a specific region of interest (ROI). ROIs could be found, displayed, and analyzed

Manipulating Images in Various Domains

One of the most useful tools in image processing is the ability to transform an image from one domain to another. Extra information can be extracted from images displayed in regularity, instance incidence, Hough, and Radon domains.

Enhancing Contrast and Filtering

Complementary along with filtering afford the capacity to smooth, sharpen, enhance edges and reduce noise within images.

Extracting and Analyzing Shapes

Morphological operations provide a means of determining underlying image structures. With this combination, these routines afford the ability to emphasize, extract, and examine features within an image.

Result and analysis

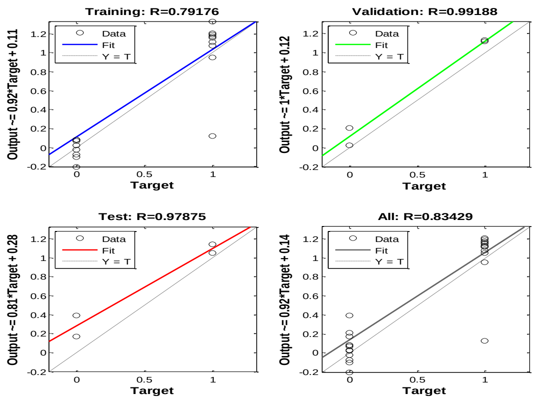

Figure 1: Validation Graph

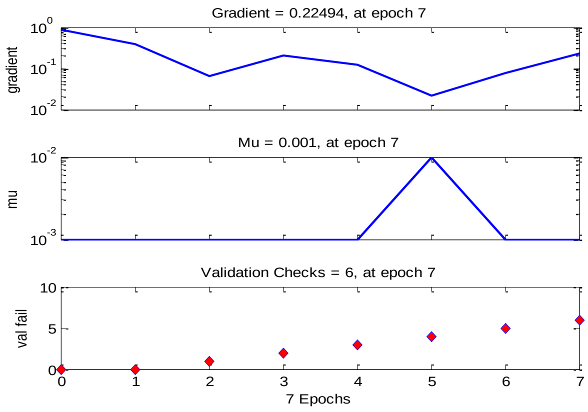

Figure 2: Gradient Graph

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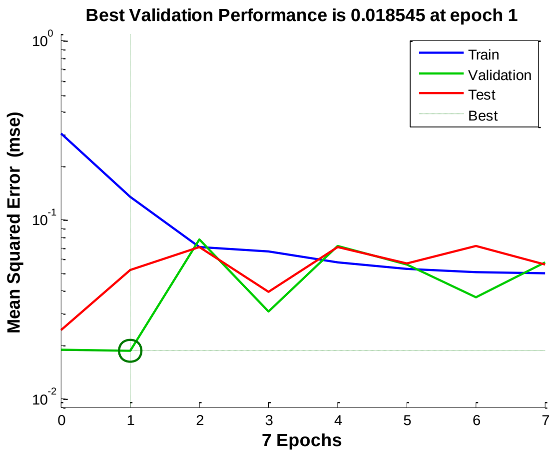

Figure 3: Validation Performance graph

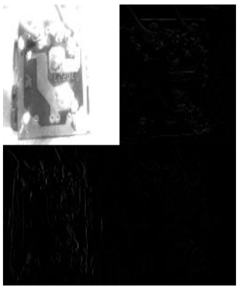

Figure 4: Input images

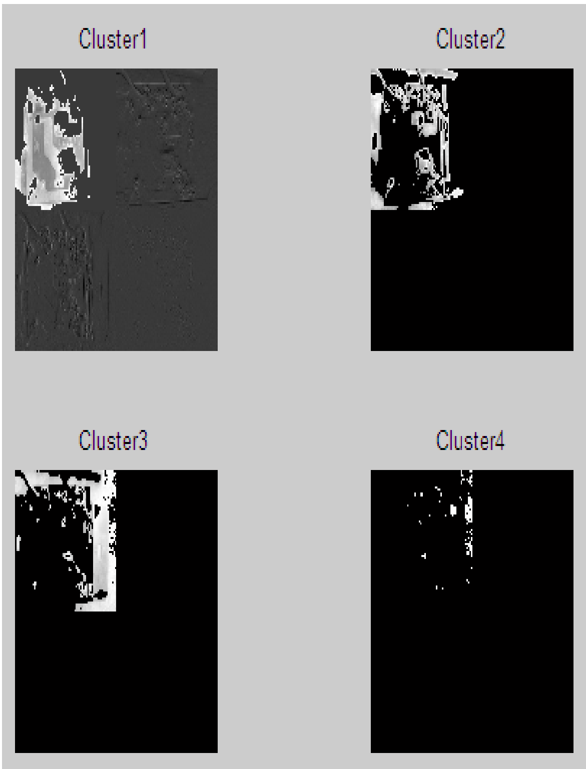

Figure 5: clustering images

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CONCLUSION

This paper summarizes the inspection of different parameters involved in cutting tool surface measurement and welding defect measurement using Image processing technique. Here discussions were made on measurement and inspection of Surface roughness, Tool wear, Tool profile, Thickness of coating done on tool and welding defects done by image processing technique using MATLAB software. From the literature review it was evident that the results obtained in conventional method of inspection and the image processing technique are comparable. Welding and soldering are similar type of processes. From this the paper would exploit that because of the successful implementation of this technique in the above discussions, this technique may also be applied for inspection of soldering defects. This paper will help in developing a specialized inspection system particularly for inspection of soldering in reduced production cost and minimised time.

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