

PCB Fault Detection using Embedded Image Processing

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Abstract: Initially, the uncovered PCBs (PCB Without components attached to it) were inspected erratically using manual inspection systems, this involves human operators. This technique is costly since it is highly error-prone Due to human error. The intention of this project thus is to supply a different low-priced and Comprehensive defect detection technique. The basic technique of the proposed technique is to detect the defect based on the digital image of the PCB using image processing techniques. We apply the machine vision concept to inspect the bare PCB. We first compare a standard PCB image with a PCB image to be inspected using a simple difference algorithm that can detect the defected region. Image difference method is one of the simplest ways for the examination of the PCB defects.

Keywords: Matlab, PIC microcontroller, Conveyer, PCB database etc.

I. INTRODUCTION

Production of the printed circuit board (PCB) is one of the important key components. In the most of the electronics industries the latest existing technology is advanced to full Digital implementation, it is envisioned that the manufacturing of PCB will be ever growing. It is Very important to produce the PCB with zero-defects. This is to ensure a high quality PCB that translates to unfailling and quality digital end products. Initially, the uncovered PCBs (PCB Without components attached to it) were inspected erratically using manual inspection systems, this involves human operators. This technique is costly since it is highly error-prone Due to human error. A more urbane way of doing the scrutiny is the utilization of in-house Circuit testing (ICT) technique. This technique uses a very expensive machine that checks the Conductivity of the PCB using probes. However, the drawback of this technique is it can only Detect defects that are based on either shorts or open. So it is crucial to provide an unusual inexpensive and comprehensive defect detection technique. The basic technique of the proposed technique is to identify the defect based on the digital image of the PCB using Image processing techniques. The intention of this project thus is to supply a different low-priced and Comprehensive defect detection technique. The basic technique of the proposed technique is to detect the defect based on the digital image of the PCB using image processing techniques. We apply the machine vision concept to inspect the unadorned PCB. We first compare a standard PCB image with a PCB image to be inspected using a simple difference algorithm that can spot the defected region. The image difference method is one of the simplest ways for the examination of the PCB defects. The defects like mislaid hole, over and under etching, erroneous Hole size defects, missing conductor and break lines etc. will get detected in this project.

The Primary concern of this project is to make use the advantage of image difference operation and extraction of features using regional properties in order to detect and to classify the Defect with minimum inspection time.

II. MOTIVATION

This project is motivated primarily by the need for more efficient methods in scrutiny of the PCB plate in the PCB fabrication process. Normally, a pair of operators is allocated in each post to physically confirm the PCB plates. This technique is not inexpensive in a long run as it takes many man hours. In addition, humans are used to building mistakes especially due to fatigue. Moreover, it is not possible to check the total PCB panels at each position without any delay. Instead, the printed laminate is tested a certain interval of Quantity for manual inspection. As the electronic circuitry technology advances, the PCB Pattern becomes denser and complicated to make probable lesser end stuff. Thus, manual Inspection is not valid anymore. Meanwhile, the advances in computers in phrase of elevated Speed, huge memory with small cost has resulted in better and cheaper equipment for image Processing. Hence, there subsists a prospect of introducing and implementing a computerized PCB inspection system to remove the subjective aspects of manual inspection. At the same time, the automated PCB examination system provides real time assessment of the PCB

III. RELATED WORK

Many vital applications of vision are found in manufacturing and defense industries. In particular, the areas in manufacturing where vision plays a major role are inspection, measurements and some assembly tasks. The order among these topics closely reflects the manufacturing needs. In furthestmost mass production, manufacturing facilities, an attempt is made to achieve 100% quality assurance of all the parts, subassemblies, and finished products. One of the most difficult tasks in this process is that of examining for visual appearance an inspection that seeks to identify both functional and cosmetic defects. With the advances in computers (including high speed, large memory and low cost).image processing, pattern recognition, and artificial intelligence have both resulted in the better and cheaper equipment for industrial image analysis. This development has totally

made the electronics industry active in applying automated visual inspection of manufacturing/fabricating processes that contain printed circuit boards, IC chips, photo marks, etc.

Human operators monitor the results of the more than 50 process steps required to fabricate a printed circuit board. They simply inspect the work visually against the prescribed standards. The decisions made by these human inspectors often involve subjective judgment, in addition to being labor rigorous and therefore are very costly, whereas automatic inspection systems don't get tired, don't suffer burnouts, and are consistent day in and day out. Applied at each appropriate step of the assembly process they can prevent value being added after a defect has occurred, reduce rework costs, and make electrical testing more efficient. All of this means improved quality at lower cost.

Most vision system for automated industrial inspection is custom designed, so they are only suitable for one specific application. Number of different types of approaches for inspection of PCBs using image processing has been reported over the last two decades. The following survey is an attempt to put together the advances made exclusively in field of bare PCBs inspection. In the following survey some techniques and methods of bare PCBs inspection system have examined. This survey concentrates on analysis of PCB images and defects detection strategies, which include different techniques, limitations of some systems etc.

PCB Inspection Approaches

Eduardo has grouped the conventional visual inspection tasks into three broad categories based on the types of defects they detect:

1. Dimensional verification
2. Surface detection
3. Inspection of compactness

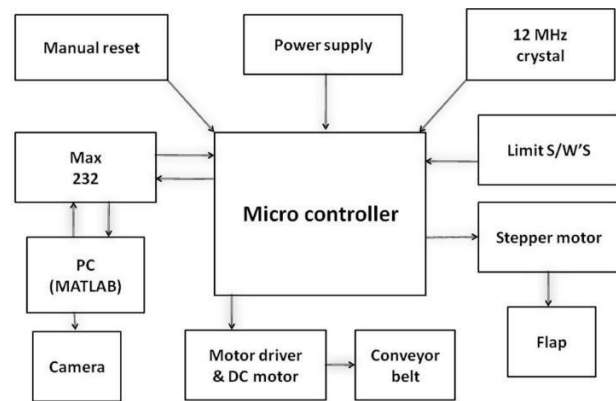
The conventional PCB bare board inspection algorithms could as well be put into these categories. Numerous PCB inspection algorithms have been proposed in the literature to date. Divided the PCB inspection algorithms into three main categories:

Reference comparison (reference-based) approach, Design-Rule checking (non-referential) approach and Hybrid approach which involved a mixture of reference comparison and design-rule approach.

The reference comparison approach use all the informative knowledge of the circuit which is to be test, whereas the non-referential approaches make use of all the informative knowledge of properties common to a circuit family but it does not only use information of the specific circuit under test. Generally there are two types of reference comparison methods which are most probably used like the simpler approaches which just involve some kind of direct image comparison that includes comparison between pixels in the test image and in an idealized reference image. Many advanced approaches offers recognition of circuit features in the test image by a comparing it against a set of

reference features. The non-referential approaches either work on the assumption that features are simple geometric shapes and the defects are unexpected irregular features or on directly verifying the design rules .Basically these methods, use local neighborhood processing techniques over the image to be inspired. In these methods, the task is to determine whereas each feature falls within the required dimensions. This approach does not require precise alignment, test might miss large flaws and distorted feature.

IV. SYSTEM ARCHITECTURE



Hardware Part

For the hardware part of the project, PIC Microcontroller is used for the controlling purpose. Hardware will be made such that, there will be a conveyor belt on which PCBs will be kept, conveyor will be run with the help of DC motors. On the top of this assembly, there will be a webcam, which will be used to capture the snapshot of PCB. This snapshot will be stored on personal computer, to which webcam is connected. Then further process will be carried out in MATLAB. The challenging part is to create proper synchronization between hardware and software part.

Following are the main components which will be used in implementation of hardware.

1 PIC controller

This is the heart of the system. PIC18F452 is used for the purpose of controlling. It is high performance controller, and an enhanced flash microcontroller. It is a 40-pin IC and is self-programmable. It has 10-bit ADC and supports RS232 communication. It has 5 I/O ports and 32KB flash memory.

2 DC Motor

DC motors are more preferable over other motors when it comes to speed, size and cost. When interfaced to the controller its speed, direction of rotation can be controlled. Here a DC motor of 3" diameter motor is used. When it comes preferable over all other types of motors .When it interfaced with controller its speed can be control, direction of rotation can be cont motor. Generally for conveyor system, DC motors are preferable because it allows stable speed Control even with fluctuating load and offer constant torque over wide range of speed. It absorbs

the sudden rises in load easily.

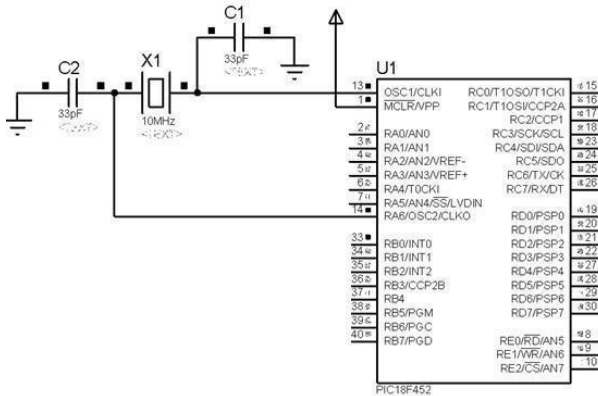


Figure2. Pin diagram of PIC18F452

3 DC Motor Driver

L293D is used for interfacing as H-Bridge is preferable to interface the DC motor with the driver. It is a dual H-Bridge motor driver so using one driver IC we can interface it to two DC motor. These motors can be controlled in both clockwise and anti-clockwise direction. It has current of 600mA and peak current of 1.2A per channel. Output supply has wide range of 4.5V to 36V it makes the best choice. Its specifications are:

- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Output Current 1 A per Channel (600 mA for L293D).
- High noise immunity input

4 MAX232

MAX232 is used in RS232 communication with modern PC applications. It converts signal from an Rs232 serial port to signal suitable for use in TTL compatible digital logic circuit. Basically it's a component for building RS232 hardware logic directly so we will be using this in our part.

5 USB to Serial Converter Cable

These USB to serial converter cables makes easy to connect an RS232 serial device to our PC. It uses 2.0.port with up to 230kbps data transfer rate. This cable is about 3foot long and has DB9 male connector on one of its end, while it has USB connector at its other end.

6 Rs232 Interface

RS232 interface is used to facilitate communication between PIC-microcontroller and third Party devices like PC serial ports, mobile communications systems etc. RS232 standard is an asynchronous serial communication method. That means the information is sent one bit at a time. This serial communication standard is used for many tasks like for sending the commands to PC, sending debug information from microcontroller to a terminal, for downloading new firmware to the microcontroller and many other things.

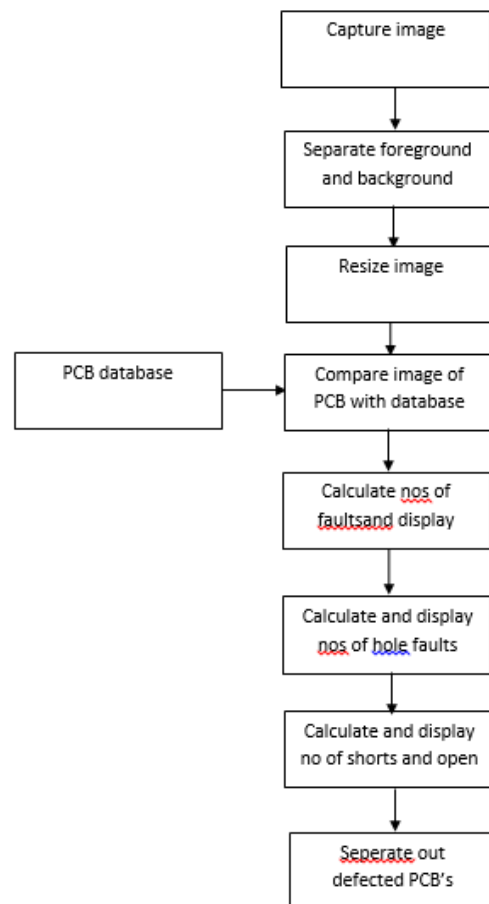
7 Camera

A webcam of model number IT306WC is used. It offers the features like its image resolution is 30 Megapixels, frame rate is up to 30fps, image format is RGB, image can be flip horizontally or vertically and its power consumption is up to 160mW. I/O can be interface using USB interface.

IT-306WC Specifications:

- Image Sensor: CMOS sensor
- Image Resolution: 640x480 (30MP)
- Frame Rate: Up to 30fps
- Focus Distance: Minimum 4cm
- Lens View Angle: 54 Degree
- I/O Interface: USB 2.0
- Image Format: RGB
- Power Consumption: 160mW

SOFTWARE DESIGNING FLOW



3.3.1 Image Acquisition

The process of choosing the image and giving to system as an input is called image acquisition. Quality of acquiring image is one of important technology depends on camera. When the camera devices are determined, it is crucial to provide proper illumination methods to ensure image quality. When extracting images, the luminary intensity and the stability of the auxiliary light source have huge impacts on the image quality. Too weak or too strong light will cause the extreme deterioration of the image quality.

Illumination is actually the most important factor that diminishes the performance of our design. Furthermore the PCB has high light reflection; it acts like a mirror, which will cause shadows of the object images when the images come into being by the top light source, which impacts the image quality greatly. Secondly, the impact of environment light should be reduced so that the objective features of images captured have less distortion and the computing complexity of image processing algorithms can be reduced.

The environment light in laboratories is commonly uniform, but the time-varying noise can make a great impact on the environment light in factories. So, we need shield the environmental light or enhance the light intensity to remove or weaken the impact of environmental light. When good illumination conditions are satisfied, our design is robust.

Height in between the camera and the examined PCBs is set to 34 cm as this is the highest available distance for the camera stand that can be set up such that camera can grab the entire PCB images. There are three kinds of camera data transmitting modes: USB, Camera Link, Gigabit Ethernet ports also we have used USB cable. The PCB image resolution is usually greater than 600dpi, which means that the 10 mil width wire of PCB just inhabits more than 6 pixels in the image.

Images captured by camera are RG B form, so it has to convert in grey scale as it is necessary for image pre-processing. Detection and classification algorithms are developed and verified in MATLAB R2013b environment by employing Image Processing Toolbox, on Windows 8 platform, with Pentium Intel® Core™ i3 personal computer. For image is needed to be enhanced and make it suitable to being processed this can done in the image pre-processing stage.

3.3.2 Image Processing

Pre-processing is done to enhance the quality of PCB images. This step is to increase accuracy of total processing part. The acquired image is converted to binary image, where the image is represented just in two pixel value

1. RGB to gray conversion

Image which captured by the given camera is in RGB format. To alleviate the influence of inconsistent colors, we first convert color images into gray scale. As it is essential for further processing part. These means that the whole image is now represented in 256 pixel values. Here 0 represents a black pixel while 255 represent a white pixel value. This conversion can be done using MATLAB software.

2. Binarisation

It is a method to convert to gray-scale image into only two pixel format. Thresholding is a method to convert a gray scale image into a binary image so that objects of interest are separated from the background. In the PCB inspection system, the trace pattern of the PCB is segmented as objects of interest by the thresholding method. The thresholding algorithm involves simply setting all pixel values to a value of zero or one depending on whether the

gray level at each pixel is greater than or less than a threshold. The difficulty with this method is to select an ideal threshold value. Especially when the area scan camera is used, it is very hard to acquire images of uniform intensity due to the characteristics of the lighting source and camera lens. Binary image ready for image subtraction algorithm.

3. Noise reduction

Most camera noises can be divided into two types: high frequency noise and salt-and-pepper noise. The Gaussian noise usually occurs at the time of image capture. It is possible to filter out the noise by employing features of the Gaussian distribution, and uses low pass filter or morphology operations to filter out regions with high frequencies. The salt-and-pepper noise usually occurs in the process of digitalization in the camera, for example, errors in the memory location. This type of noise can be reduced using either the median filter. Using morphology function removes pixels which do not belong to object of interest. It removes all connected components that have fewer than 40 pixels, which we do not need.

3.3.3 Image Subtraction

Image difference is the foremost step in the PCB inspection algorithm carried out by Wen-Yen [12]. Image subtraction operation involves pixel-by-pixel scanning. Thus, image difference operation is considered for the assessment. It is possible to detect the defects occur on the test PCB image by simply applying the image difference operation between the reference PCB image and the tested PCB image. A new image is acquired as a result of comparison of both the images pixel-by-pixel by XOR logic operator. This operation is also called as image comparison operation. As time is one of the industries major factors, it is essential to see the performance of the algorithm in term of inspection time of the full resolution image difference operation

3.3.4 Feature Extraction

The next step is to compute the image features intended to extract. The features chosen had to be discriminative as well as sufficient in describing the object presented in each image. Therefore MATLAB code is developed using the region props function from Image Processing toolbox. We extract s geometric features from the Image using region props, Region props in nothing but short form properties Regional. The function region props takes an image and can compute a number of useful features about each object This function measures a set of properties of difference of reference image and the test image, like its Eccentricity, Major axis Length, Minor Axis Length, area, and Orientation etc. all the features computed should be normalized, so that they would be weight balanced. A region prop calculates the properties of image region. It measures set of properties for each object in binary image. It computes shape measurement.

V. RESULTS

In this system, we are displaying results on GUI because in this user can load the image, starts the processing on it

by selecting given graphical elements for it .So it is well known that GUI is very easy to use as it does not need more experience or training to use.

Following images shows final output displayed on GUI. We have developed our model on a real time system and its result is getting displayed on GUI. Experimental result shows that the test image is grabbed and processed by the proposed algorithm within few second.

When start button on GUI is get pressed then DC motors starts running so that PCB also moves towards the camera. In the first box we can see PCB image which is already stored in PC, whereas second box shows real time PCB image. We can see processing time on the screen. In the third box we can see defects which are obtained after performing difference operation. After some few seconds it shows number of defects, and among them how many are line defects and hole defects. In this way GUI brings the user closer to the programming environment and also keeps him away from the programming overheads. In fig. 4.1 and fig. 4.2 we see results obtained

for different defected PCB. At the time of image acquisition and loading it, we can see its processing time.

The camera's resolution is closely directly affects the system accuracy. In general, high resolution means better measurement accuracy, But the system's performance-to-price ratio also should be considered Height in between the camera and the inspected PCBs is set to 34 cm as this is the highest available distance for the camera stand that can be set up such that camera can grab the entire PCB images.

VI. CONCLUSION

The system was proven to be an alternative way to efficiently detect the defects. Furthermore, the system is cheap as mechanical alignment facility is not so expensive. Several experiments were performed to validate the performance of the PCB inspection system. The computational time for this system is about 17.95 seconds. Computational time could be improved further by implementing the examination on high performance computing platform or using small dimension of PCB samples.

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