CORE
Metadata, citation and similar papers at core.ac.uk
Provided by UUM Repository

Reverse Engineering of Printed Circuit Boards: A Conceptual Idea

Shahrul Azmi Mohd Yusof, Ruzinoor Che Mat, Abdul Nasir Zulkifli, Ruslizam Daud

Faculty of Management of Technology
Universiti Utara Malaysia
06010 UUM Sintok
Kedah

(shahrulazmi@uum.edu.my, ruzinoor@uum.edu.my, nasirzul@uum.edu.my, ruslizam@uum.edu.my)

Abstract- **With the advent of new technologies, many electronic manufacturing companies are competing among each other to capture the market and at the same to compete globally. For electronic equipment and appliances which are based on Printed Circuit Boards (PCB), new generations of PCB's are being produced to suit the requirements of new products. This development can lead to waste and inefficiency when perfectly serviceable electronic components and appliances have to be scrapped because the spare PCB's are no longer available from the original equipment manufacturer OEM or are already obsolete. There is a need to do reverse engineer or re-engineering on obsolete PCB's or PCB's which is no longer in production. Obsolete PCB's is no longer manufactured and replacements are required. There might be a need to modify the current design but the necessary files are either lost or corrupt. This paper discusses a preliminary study in developing a new conceptual idea of producing reverse engineered PCB's utilizing vectorization technique and electronic design software. The aim of this study is to create a new framework which will allow replacement of obsolete PCB's.**

Keywords: *PCB's, Reverse Engineering and* vectorization.

I. INTRODUCTION

One of the largest areas in electronic industry is PCB design. The implementation of PCB has been described as the most expensive and time-consuming effort in the product design cycle. A PCB complexity varies from simple single layer PCB to multi-layered PCB. The PCB design phase involves creating a schematic diagram. This includes collecting the symbols for all of the components needed for the PCB to function as designed. The schematic diagram must also represent the interconnections between the components.

A. PCB Production Process

There are several basic steps involved in producing a PCB. The major steps in the PCB design and fabrication process are as follows [1].

1) Design and test the prototype circuit which is done by hand
2) Capture the circuit's schematic using CAD or electronic simulation software
3) Perform the physical layout of the circuit PCB software to create Gerber files
4) Fabricate, populate and test the physical working PCB which is either done by hand or by machine.

PCB can generally be classified into four basic categories which is;

1) Analog – boards populated primarily with discrete components;
2) Digital – boards populated primarily with logic devices;
3) Mixed analog with digital;
4) Boards with special mechanical considerations. This research will involve a digital board with a simple circuitry on the boards.

B. Research Outline

The aim of this research is creating a new framework for PCB Reverse Engineering. Normally it can be done by Electronic Design Software such as Electronic Workbench, LabView, Edwin XP, PSpice, MultiSIM and etc (see Figure 1.0). The process of reverse engineering starts from an existing Gerber data or obsolete PCB and manually reversing the designing sequence until new PCB has been manufactured which include manual mapping of the PCB. The difference with this research is that it involved a PCB scanning from a raw PCB material and then raster to vector conversion (vectorization) is done to the scanned image. Vectorization is the process where raw artwork can be converted into vector image that can be viewed on the computer to be edited and used for design and simulation. This process can be done using raster to vector software. The next process is creating a Gerber files using Electronic Design Software (EDS). The final step is to create the complete Gerber files. Now all the Gerber files necessary to physically create the PCB are available. These Gerber files are used along with the prototyping machine to create the PCB substrate. The components are then added and soldered into place, completing the PCB.

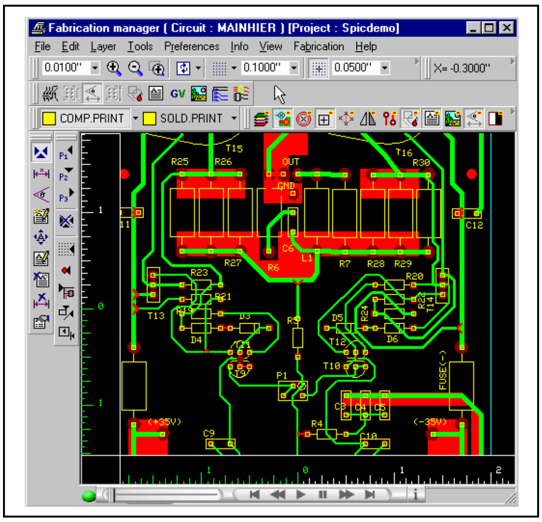

Figure 1.0: PCB Image from Edwin XP [13]

II. PREVIOUS WORK ON PCB REVERSE ENGINEERING

A. *Introduction*

One of the problems of PCB Reverse Engineering is that it takes weeks to reconstruct back the circuitry from raw original PCB into complete workable simulated PCB on an Electronic Design Software using manual hand mapping process. This is done by tracing back the wiring track connection and identifying the components. Even though after this process is completed, there might be errors in connection in terms of wiring. This problem will be worse for more complex circuitry.

Currently, there is a solution for PCB reverse engineering which claim that their solutions can work on simple single-sided to complex mutli-layer PCB's, bare or assembled. It has the capability of PCB reverse engineering with the complete design data package, which includes the CAD design database, Gerber data, and schematic and fabrication drawings for any particular design.

The technique is able to redesign or even reverse engineer any bare board, artwork, paper, mylars, or schematics, this is often time consuming since the typical turnaround for PCB design is 2 weeks. Moreover, PCB design tends to be rather expensive given that more expensive CAD systems must be utilized to complete the designs [2].

B. *Scanning and Image Capturing Process*

Traditionally, optical inspection using pixel counting algorithms such as object recognition, blob analysis and template matching.

1) The method of object recognition identifies image patterns corresponding to physical objectives in a view. It compares the new view with an ideal image of the object and reports any differences that may occur.

2) Blob Analysis first requires separating the object from the background. Using a pixel-based image, the object pixels are grouped to form a blob. The geometry of the blob is then used to identify the object, locate and inspect.

3) In template matching, the system must be firstly trained by storing a pixel image of the object or component. The product to be inspected, or the printed circuit board, is then scanned to find images that match the stored pixel object. The most successful method uses normalized gray scale correlation as a measure of the match.

Currently, there are several methods of inspection of the paste deposition prior to fine pitch placement. The methods available are utilizing laser scanning and x-ray technique. The solution that is most widely accepted today is the Automatic Optical Inspection (AOI), which uses single, dual or multiple camera configurations. Laser scanning is mainly being used for solder paste deposition inspection, while X-Ray is being sued as a diagnosis tool after in Circuit Test or as a sampling method for detection of bad joints after re-flow.

In order to capture the best image, there many variations need to be considered include; illumination density and distribution, object surface characteristics, orientation in relation to the camera or scanner, position in relation to the pixel grid, optical and electronic characteristic of the hardware being sues such as the camera, lightning focus, distortion and noise, scene clutter and occlusion.[3]

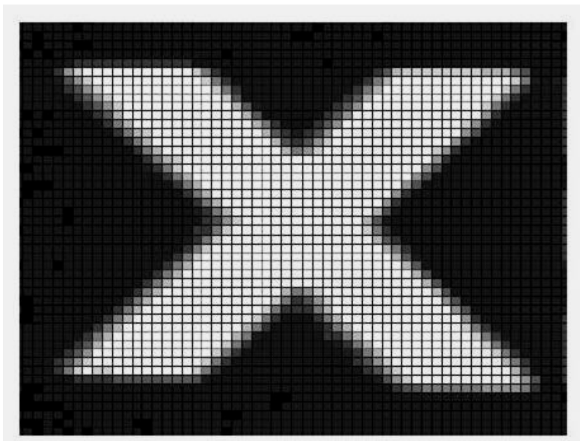

Figure 2.0: The example of grey scale image [3]

The images that have been captured will be converted from RGB to gray scale image using the own developed program, using MathCAD or Matlab. Using gray scale correlation, most system stores an image that is considered to be an acceptable representation of the component to be inspected. This image later compared to other image during production, and comparison of the levels of the gray of each pixel and the number of pixels that match the stored image defines whether is worthy of being considered a good enough match to be recognized and proceed to vectorization process [4].

C. Vectorization

The history of vectorization from scanned images started at the end of the sixties to convert raster data into vectorial information by using macro-computer. Then this technology was applied to capture cartographic information, even to develop technology based on the capture of particle traces in nuclear physics [11]. The role of vectorization is to convert graphic objects in a raster image to vector form. Basic vectorization concerns grouping the raster image pixels into raw line fragments. The resulting objects may be bars or polylines. These objects can be refined during the post-processing phase using line fitting and line extending processes [12].

Hilaire [10] define the vectorization as the process that extracts shapes from a digitized document image. Shapes found in the paper hardcopy of the document usually consist of straight line segments, arcs, and circles, all with possible different styles and widths. Common sources of such documents include mechanical drawings, electrical and electronic drawings, and architectural maps. Though a large number of vectorization methods and systems are now available ([7],[8],[9]).

The current vectorization methods can be classified into three categories: thinking-based [5] contour based [6], and Run Length Encoding (RLE)-based [14]. Thinning-based method usually employs an iterative boundary erosion process to remove outer pixels, until only one-pixel-wide skeleton remain. The contour based method extracts image contours first then finds the medial axis between the contours. The RLE method constructs a line adjacency graph after computing the run-length encoding of an image.

III. Proposed Framework

The proposed framework in this paper is only a preliminary idea to complete the Reverse Engineering process for PCB. There are some additional steps may be involved in this framework. Figure 3.0 show the proposed research framework.

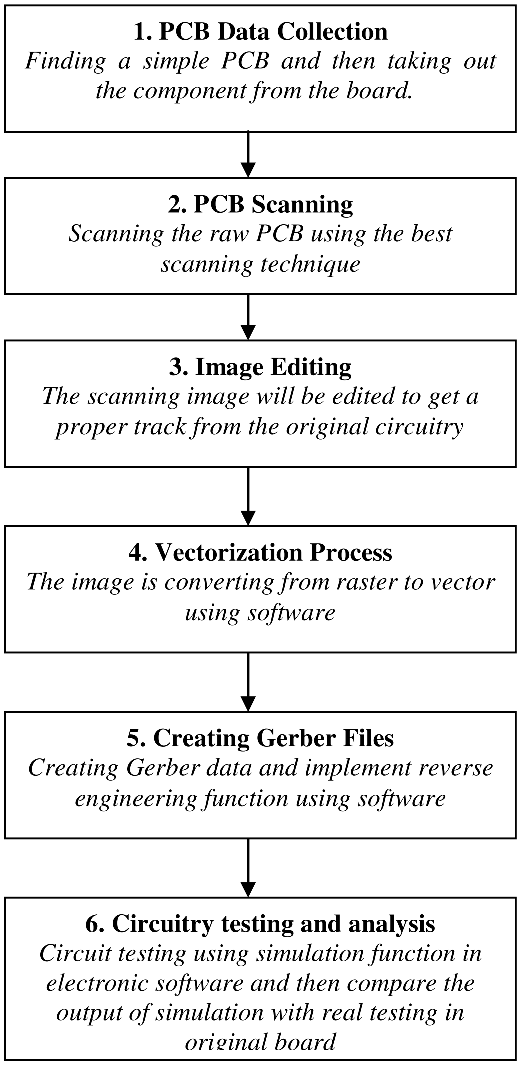

Figure 3.0: Proposed research framework

IV. Discussion

Based on the literature review, there are high possibilities to produce a new framework for PCB reverse engineering. It is because there are many companies involve in providing Reverse Engineering capability for PCB. The idea of this research is to produce a new technique of Reverse Engineering for PCB in different way which aims to reduce the time and offer a quality PCB.

V. Conclusion

By creating a new framework of PCB Reverse Engineering to be used in the industry, it will be able to help industry to manage missing Gerber data files which can be time consuming and very expensive to reconstruct back. Other than that, hopefully it will reduce the PCB reconstructing time which currently 2 weeks time. The obsolete PCB also can be replaced by a new PCB design.

ACKNOWLEDGMENT

Thanks for all the research group members for the contribution in completing this paper for the conference.

REFERENCES

[1] Michigan State University (MSU) (2000),"How to create a Printed Circuit Board", Technical Report, Department of Electrical and Computer Engineering,Access on [19 April 2004] http://www.egr.msu.edu/eceshop/pdf/an_pcb_t23.pdf

[2] LSP Corporation (2004), "Reverse Engineering Solutions", Access on [19 April 2004] http://www.lspcorp.com/pcb002.html

[3] Mark J. Norris (2002), "Advances in Automatic Optical Inspection: Gray Scale Correlation vs. Vectorial Imaging" Journal of SMT, Volume 15 Issue 1, Vision Inspection Technology, LLC, Haverhill, MA

[4] P. Cielo (1987) "Optical Technique for Industrial Inspection" Academic Press. Inc. Harcourt Brace Jovanovich Publishers

[5] Datta, A., Parui, S.K. (1994), "A robust parallel thinning algorithm for binary images", Pattern Recognition, Vol. 27, No. 9, pp. 1181 – 1192

[6] Hori, O., Tanigawa, S. (1993), "Raster-to-vector conversion by line fitting based on contours and skeletons, Proceeding of the International Conference on Document Analysis and Recognition, pp. 353-358.

[7] Tombre, K., Ah-Soon, C., Dosch, P., Masini, G., and Tabone, S. (1999) (1996),"Stable and Robust Vectorization: How To Make the Right Choices", In Proceedings of 3rd International Workshop on Graphics Recognition, Jaipur (India), pp. 3-16.

[8] Tombre, K., and Chhabra, A.K., (1998),"Graphics Recognition-Algortihms and Systems", volume 1389 of Lecture Notes in Computer Science. Springer-Verlag.

[9] Wenyin, L., and Dori, D., (1998), "A Survey of Non-Thinning Based Vectorization Methods". In A. Amin, D. Dori, P. Pudil, and H. Freeman, editors, Advances in Pattern Recognition (Proceedings of Joint IAPR Workshops SSPR'98 and SPR'98,Sydney, Australia), pp. 230–241.

[10] Hilaire, X., (1996)," A Matching Scheme to Enhance Performance Evaluation of Raster-to-Vector Conversion Algorithms", Proceedings of the Seventh International Conference on Document Analysis and Recognition (ICDAR 2003), IEEE Computer Society.

[11] Gomis, J.M., Company, P., Gil, M.A.,"Vectorization in Recovering Engineering Drawings", II Seminario Italo-Spagnolo. Progettazione e Fattibilit dei Prodotti Industriali, (Not yet published), 1.998

[12] Dori, D., Liu, W., (1999),"Sparse Pixel Vectorization: An Algorithm and Its Performance Evaluation", IEEE Transactions on PAMI, Vol. 21, No. 3,pp. 202-215.

[13] Visionics (2004), "Schematic Editor", Edwin XP software. Access on [20 October 2004] http://www.edwinxp.com/xptour/demosch.html

[14] Zenzo, S.D., Cinque, L., Levialdi, S. (1996),"Run-based algorithms for binary image analysis and processing, IEEE Transition PAMI, Vol. 18, No. 1,pp. 83-89.