Визначення дефектів друкованих плат з допомогою особливих точок скелетону зображення

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Printed circuit board defects detection by specific points of image skeleton

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***Анотація*—Представлено реалізацію відомого алгоритму скелетонізації. На скелетонах знаходяться координати особливих точок. Алгоритми застосовано до друкованих плат з метою визначення координат можливих дефектів з'єднань : розривів доріжок та короткого замикання. Представлені приклади застосування алгоритму.**

***Abstract*—The known skeletonization algorithm was realized and the skeleton feature points were found. The algorithms were applied to printed circuit boards to detect the main defects : wire breaks and short circuits Some examples of applications are shown.**

Ключові слова—скелетон зображення, особливі точки, друковані плати, розриви доріжок, замикання

Keywords—skeleton, printed circuit board, defect detection, wire, break, short connection

I. Introduction

There are many works devoted to skeletonization algorithms. Main of them are listed in the survey [1]. Two examples of pixel skeletonization algorithms was introduced in [2,3] which run on the distance map of a digital figure, computed according to any among four commonly used path-based distance functions. Non-pixel-based skeletonization techniques based on a constrained Delaunay triangulation was presented in [4]. Algorithm in [5] can be used to detect some kinds of defects in PCBs. In this paper, the conception of linkage information table was presented which is regarded as correlation features of template PCBs. The designed analogic algorithms [6] to solve the problems above were tested on real-life examples using the CNN-HAB digital multiprocessor system with 1 million cell space. The work [7] considers parallelization issues for intrinsically sequential algorithms of thinning. The discussed algorithms are complicated enough, some of them use neural networks etc. In this article we present realization of very simple algorithm and its application to PCB defects detection.

II. ALGORITHM OF SKELETONIZATION

.Removing the maximum number of pixels without changing the shape of object model is called skeletonization. By this approach a skeleton should help identification of the image itself. The skeleton properties are as follows : • thinnest lines; • all segments are connected ; • lines are located in the centre of the observation objects..

The example of a letter skeleton are shown on fig. 1.

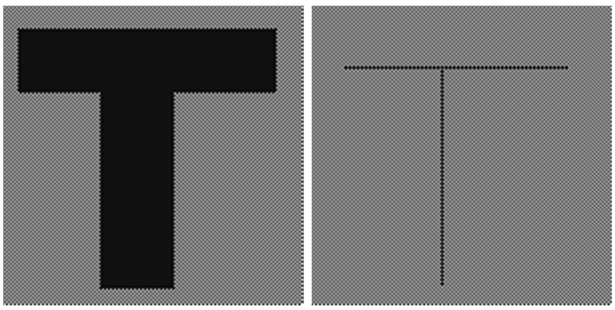


Fig. 1. Image and its skeleton

We consider the Hilditch's Algorithm [2] which is very simple for realization. The algorithm works with binary images. The main idea of the algorithm is iterative scanning window with matrix of pixel positions and eventually replacing black pixels by white ones. The window has a size of 3x3 or 4x4 positions. We consider a version of the algorithm for scanning window size of 3x3.. Then all pixels are numbered from P1 to P9 and are shown on fig.2.

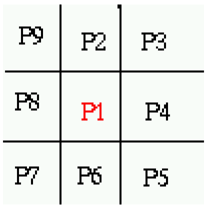


Fig. 2. Scanning window with numbered pixels

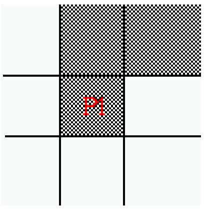
When scanning the image a decision must be taken to change or not a colour of pixel P1 (centre of window). To answer the questions about the pixel P1 colour to be left or changed in the skeleton two functions are needed to calculate:

B (P1) = number of neighbours for P1 being not null

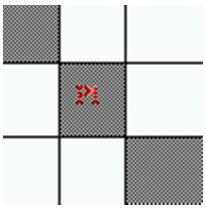
and

A (P1) = number of pairs {0,1} in order p2, p3, p4, p5, p6, p7, p8, p9, p2.

Examples of different configurations with neighbouring pixel P1 and functions for it are on fig..3.



B(p1)=2 , A(p1)=1



B(p1)=2, A(p1)=2

Fig. 3. Two variant of pixel placement in window

When scanning the surface of the image for the central and some neighbouring pixels functions B(p) and A(p). are calculated The decision to exclude the pixel P1 from the black list is not accepted, if they simultaneously don't satisfy the following conditions:

1) 2 <= B (p1) <= 6
2) A (p1) = 1,
3) p2.p4.p8 = 0 or A (p2)! = 1
4) p2.p4.p6 = 0 or A (p4)! = 1

.Scanning stops if an iteration will not cause a colour changing.

III. PCB DEFECTS DETECTION

At the beginning we consider the examples of the algorithm result for constructing the skeleton. On fig.4 we can see a set of letters, numbers, etc. and their corresponding skeletons.

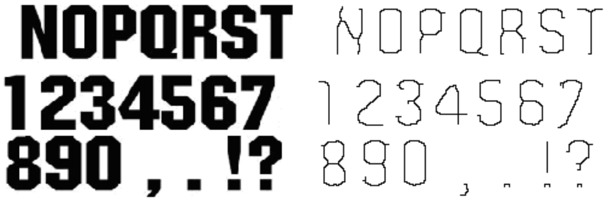


Fig. 4. Skeletons of letters and digitals

Skeleton allows to find the coordinates of specific points, namely the ends and switches of wires. An example of such singular points are shown for the letter "Y" and "X" on Fig.5. A switch - a point at which three or more lines are connected. Start and end line points also are considered as special..

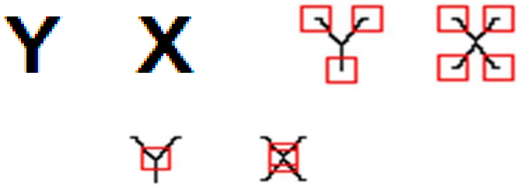


Fig. 5. Feature points: ends and switches

Tools of skeletons and special points are useful for finding defects of connections in printed circuit boards and chips. Printed circuit boards usually consists of contacts and wires that connect together certain groups of contacts. On fig.6 an example of printed circuit board without any defect is presented. On the same figure we can see corresponding skeleton with specific points : switches and ends. Switches are for all wires approaching the contacts. The wire ends are only on the right border of the image. They correspond to abrupt wires.

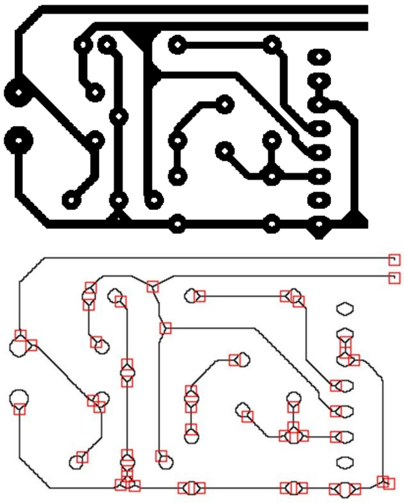


Fig. 6. PCB and its skeleton with specific points

After doing two breaks of wires by a single-pixel line we get a new version of PCB (fig.7.) and skeleton. On the skeleton we can see two gaps marked by three red rectangles on wires. Each of them indicates the coordinates of wire breaks.

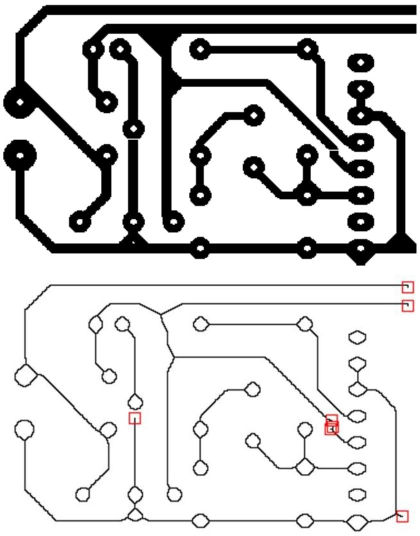


Fig. 7. PCB with defects and skeleton with their coordinates

.The skeletonization algorithm also allows to detect a short circuits of wire. We assume that short circuit is similar to a switch with four outputting lines. In contrary, a switch of wires with contacts or between themselves has three outputting lines.. On fig.8 we can see an example of PCB and its skeleton on fig.9 with two short circuit points.

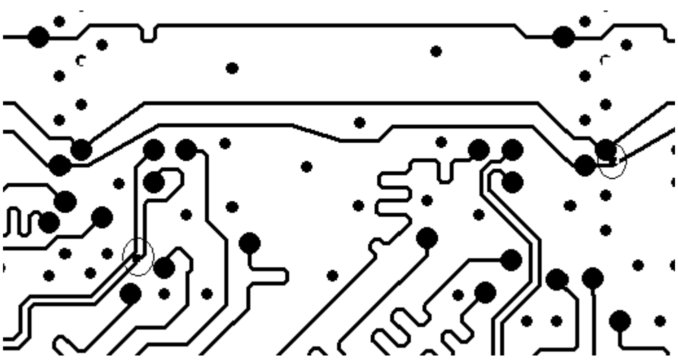


Fig. 8. PCB with short circuits of wires (two circles)

Thus, breaks in the wires for contact connections could be detected by two ways: 1) by direct analysis of the skeleton and its specific points, 2) by comparing the specific points of the skeleton of an industrial boards with skeleton points of reference template.

CONCLUSION

Simple Hilditch's skeletonization algorithm was realized and its application to process binary images was demonstrated. Two types of feature points: ends and switches of skeleton help to detect PCB defects. First ones indicate the wire breaks and the second ones – short circuits. So, the developed software can be used in automated systems of PCB defect detection.

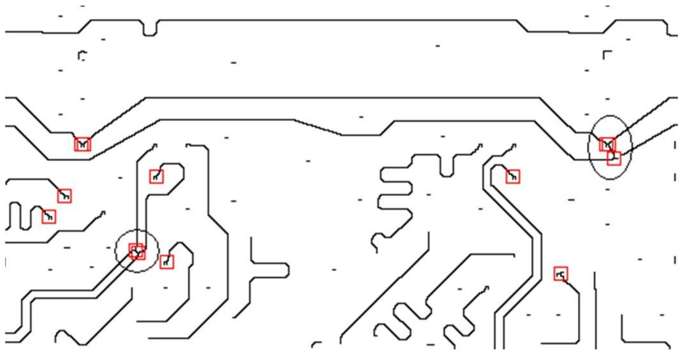


Fig. 9. Skeleton with coordinates of switches (two circles)

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