Improving the Testing Rate of Electronic Circuit Boards

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Problem statement

- Acculogic Inc. manufactures systems for testing Electronic Circuit Boards (ECBs).
- The systems are almost entirely automatic but require some human input.
- The clients of Acculogic Inc. use those systems to test batches of ECBs, and testing an ECB requires the system to carry out thousands of tests.
- To carry out a test, the system must locate the test points on an actual board.
- When carrying out the tests, the system may produce "false negatives", i.e., report a failure where there is none.
- A false negative occurs because a probe does not hit the required test point.

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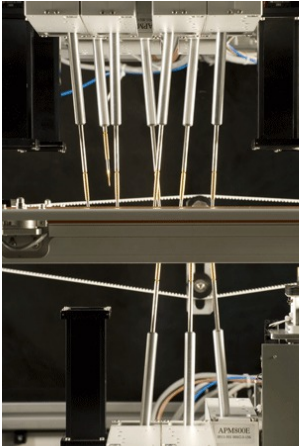
Flying Probe Systems



Problem statement (continued)

- Acculogic's systems must be improved in order to **minimize the number of false negatives**.
- Although the boards are made after a pattern stored in the computer, the precise location of a given test point varies from board to board.
- Finding the locations of test points will become more challenging as the electronic devices become smaller.
- In what follows **ideal point** will refer to a point stored in the computer and **actual point** to a point of the board being tested.
- We are looking for a **mapping** (or matching) between the set of ideal points and the set of actual points.

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The current procedure: fiducial training

- Three **fiducial points** are chosen; their ideal coordinates are known.
- An expert looks for (and finds) the corresponding **fiducial marks** on the first board of the batch.
- An actual fiducial point is at the center of its fiducial mark.
- **Reference pictures** (i.e., pictures of the fiducial marks) are taken.

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The current procedure: fiducial finding

- Once the fiducial training has been completed, every board (including the first one) is processed in turn automatically.
- Pictures of fiducial points are taken (their approximate locations being known through ideal coordinates).
- The actual coordinates of the fiducial points are obtained by making corrections after comparing the above pictures with the reference pictures.
- The mapping between the ideal fiducial points and the actual points can be extended (in a unique way) to an affine transformation between the ideal board and the current board.
- All the tests on the current board are carried out and the failed tests are recorded.

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Assumption

- Printing errors on the board are spatially correlated, so that we can define local maps between the ideal and actual boards.
- This assumption cannot be tested yet.

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How to improve fiducial training

We are proposing a new algorithm for selecting the fiducial points.

1. Four fiducial points are identified in the four corners of the board, respectively.
2. Each subgroup of three fiducial points gives rise to an affine transformation. This gives us a first group of affine transformations.
3. Construct local maps using this group of transformations.
4. Use the Next Best Pose (NBP) algorithm to select an additional fiducial point.
5. If the new fiducial point is correctly predicted by the local maps, the algorithm stops. If not, go to Step 3.

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How to improve fiducial finding

1. Select the next fiducial point (following the same order as for the first board).
2. Take a picture and compare it with the reference picture.
3. Compute the needed correction to hit the test mark and update the local maps.
4. Go back to Step 1.

Currently, the image comparison is performed with a black-box least squares method. We think it can be improved.

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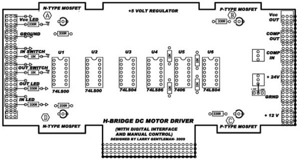
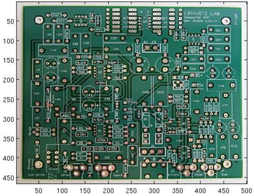
The Ideal Circuit Board

The following is the output from autocad.



A real circuit board isn't so nice.



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A possible approach: feature detection

1. Create grayscale image.
2. Apply a threshold filter to obtain an image of 0s and 1s.
3. Identify the connected components and extract geometric properties for each component like centroid, area, Euler number, etc.

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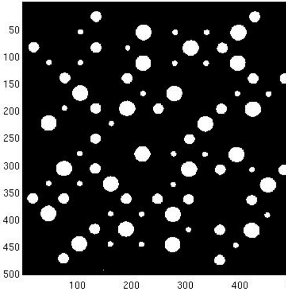
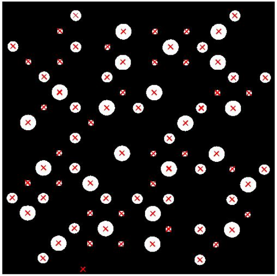
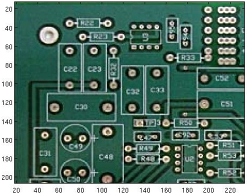
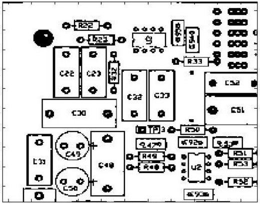
First example: A bunch of circles

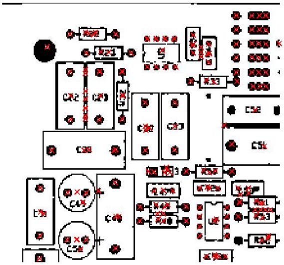




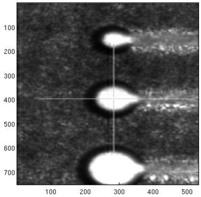
Second example: a close-up of that circuit board

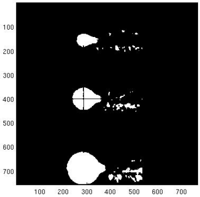


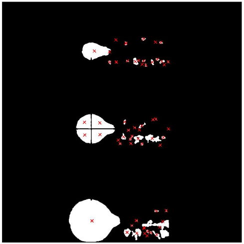




Third example: a real close-up of a real board







Second Approach: the Scale-Invariant Feature Transform (SIFT)

An All-Canadian Product! From UBC! Thank you David Lowe for inventing it!

We gratefully thank Professor Sébastien Roy (Université de Montréal) for a crash course on SIFT and the affiliated Speeded Up Robust Feature (SURF).

A second, less blurry example

General idea

Identify "key points" in the image in such a way that two images of the same thing will have the same key points even if the images are taken from different angles, different illuminations, different distances, etc.

1. For each image, identify the image's key points.
2. For each key point in the first image, try to find a corresponding key point in the second image.

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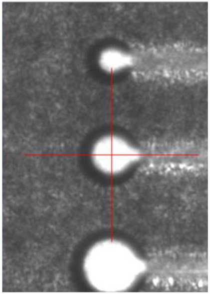

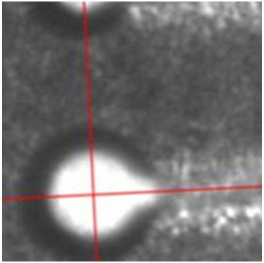

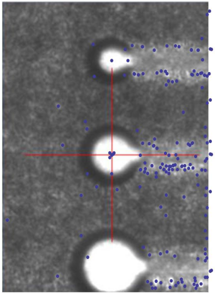

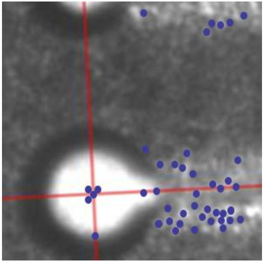

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