Template Matching

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CIS 601

Based on a project by Roland Miezianko

Agenda

- Template Matching
  - Definition and Method
  - Bi-Level Image
  - Gray-Level Image
- Matlab Example
  - Gray-Level Template Matching
  - Machine Vision Example

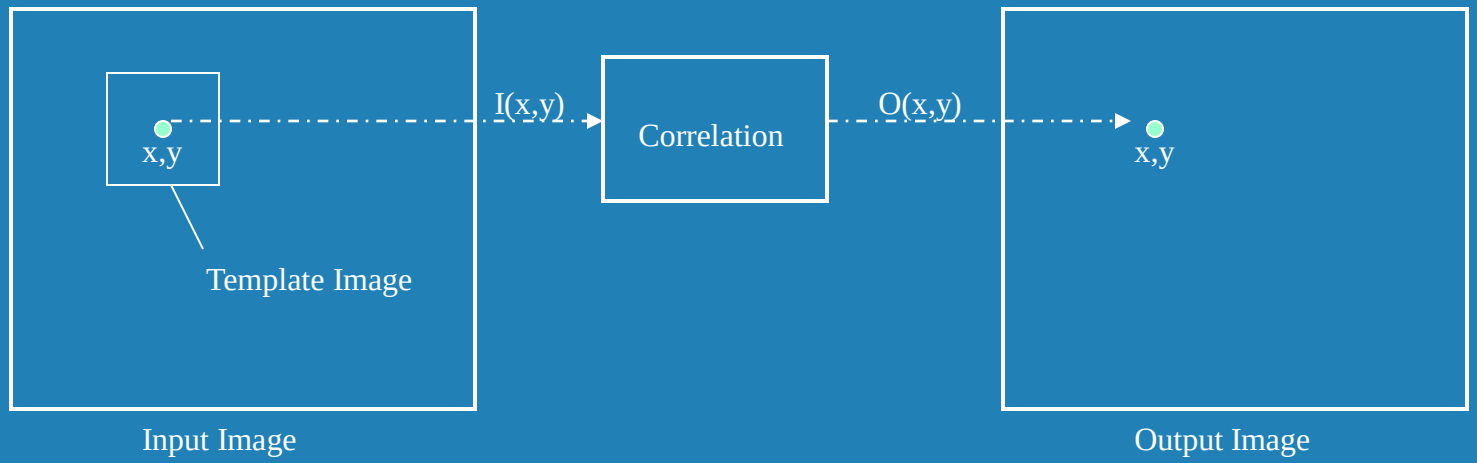
Definition

- Technique used in classifying objects.
- Template Matching techniques compare portions of images against one another.
- Sample image may be used to recognize similar objects in source image.

Definition, cont.

- If standard deviation of the template image compared to the source image is small enough, template matching may be used.
- Templates are most often used to identify printed characters, numbers, and other small, simple objects.

Method



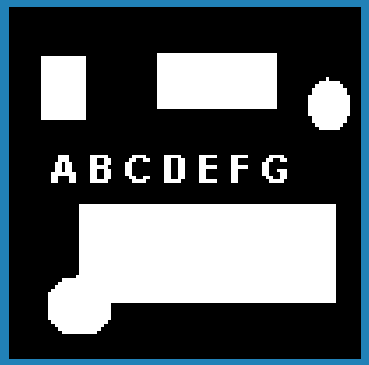
The matching process moves the template image to all possible positions in a larger source image and computes a numerical index that indicates how well the template matches the image in that position.

Match is done on a pixel-by-pixel basis.

Bi-Level Image TM

- **Template is a small image, usually a bi-level image.**
- **Find template in source image, with a Yes/No approach.**

Template

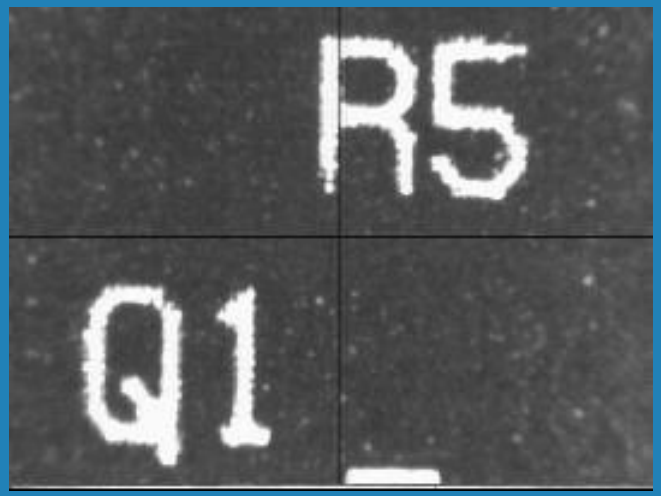


Source

Grey-Level Image TM

- When using template-matching scheme on grey-level image it is unreasonable to expect a perfect match of the grey levels.
- Instead of yes/no match at each pixel, the difference in level should be used.

Template



Source Image

Euclidean Distance

Let I be a gray level image
and g be a gray-value template of size $n \times m$.

$$d(I,g,r,c) = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{m}\left(I(r+i,c+j)-g(i,j)\right)^2}$$

In this formula (r,c) denotes the top left corner of template g.

Correlation

- ***Correlation*** **is a measure of the degree to which two variables agree, not necessary in actual value but in general behavior.**
- **The two variables are the corresponding pixel values in two images, template and source.**

Grey-Level Correlation Formula

$$cor = \frac{\sum_{i=0}^{N-1} (x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sqrt{\sum_{i=0}^{N-1} (x_i - \bar{x})^2 \cdot \sum_{i=0}^{N-1} (y_i - \bar{y})^2}}$$

x is the template gray level image

$\bar{x}$ is the average grey level in the template image

y is the source image section

$\bar{y}$ is the average grey level in the source image

N is the number of pixels in the section image

(N= template image size = columns * rows)

The value cor is between –1 and +1,
with larger values representing a stronger relationship between the two images.

Correlation is Computation Intensive

- Template image size: 53 x 48
- Source image size: 177 x 236
- Assumption: template image is inside the source image.
- Correlation (search) matrix size: 124 x 188 (177-53 x 236-48)

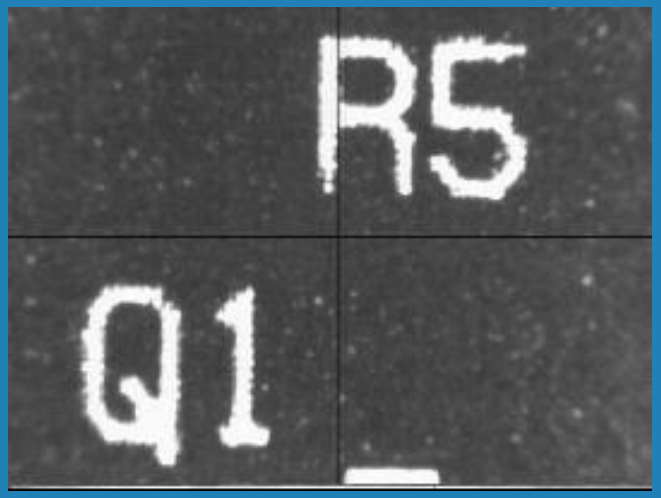
- Computation count

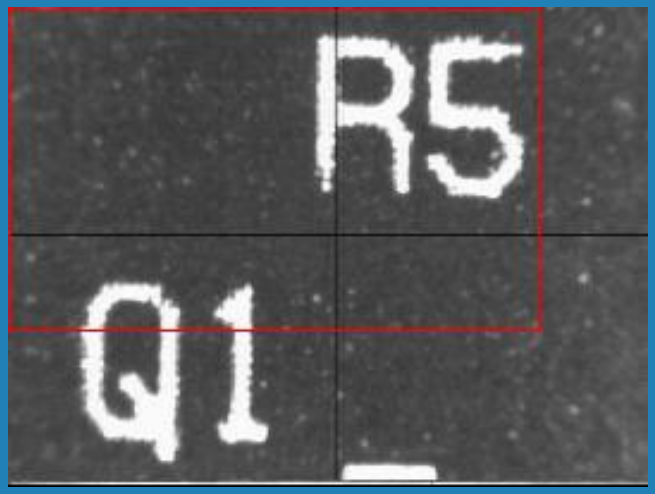
  124 x 188 x 53 x 48 = 59,305,728

Machine Vision Example

- Load printed circuit board into a machine
- Teach template image (select and store)
- Load printed circuit board
- Capture a source image and find template

Machine Vision Example





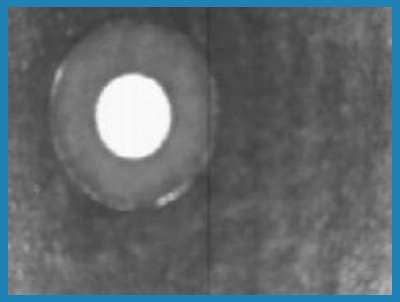
Assumptions and Limitations

1. Template is entirely located in source image
2. Partial template matching was not performed (at boundaries, within image)
3. Rotation and scaling will cause poor matches

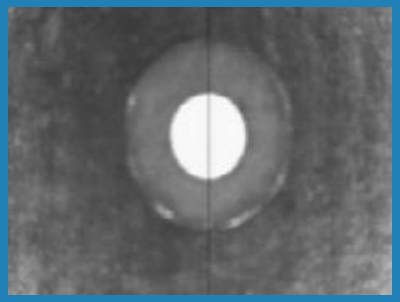
Matlab Example

Matlab Data Set

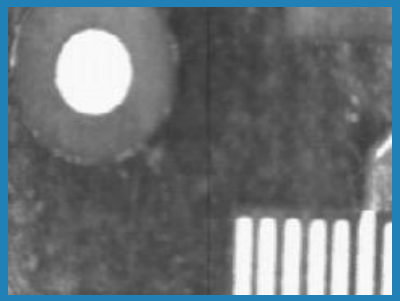
Template



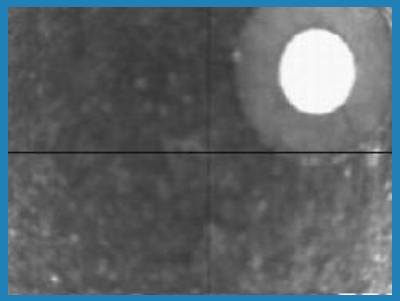
Data Set 1



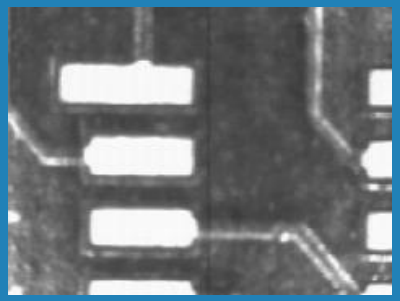
Data Set 2



Data Set 3

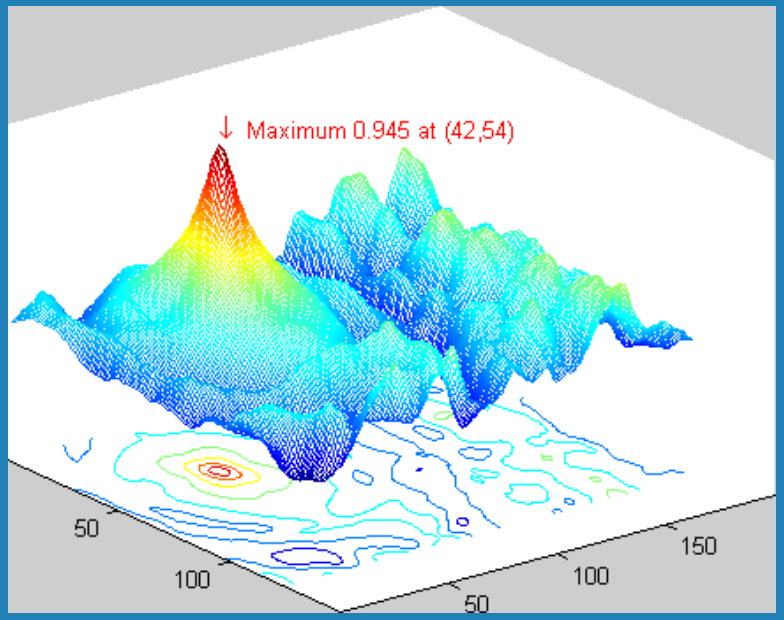


Data Set 4



Data Set 5

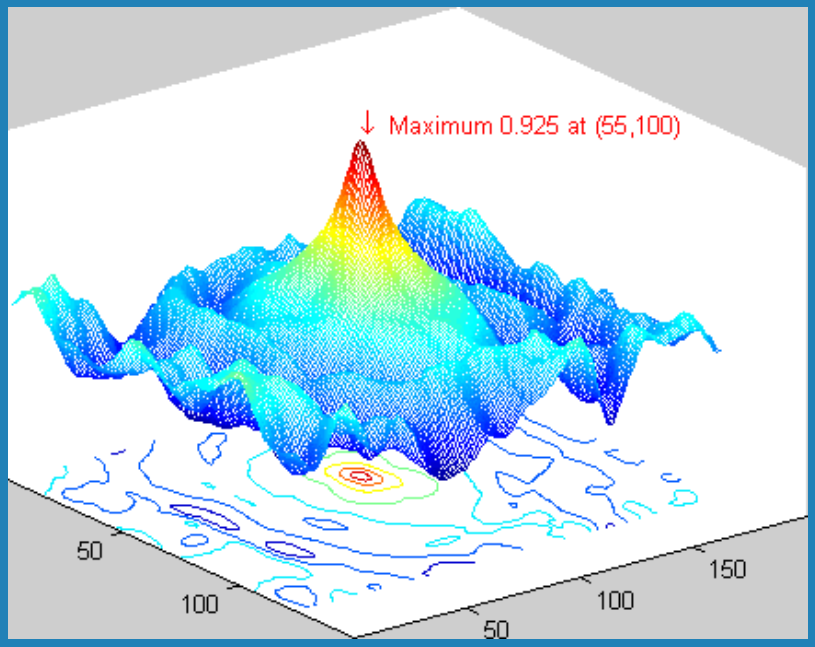
Data Set 1



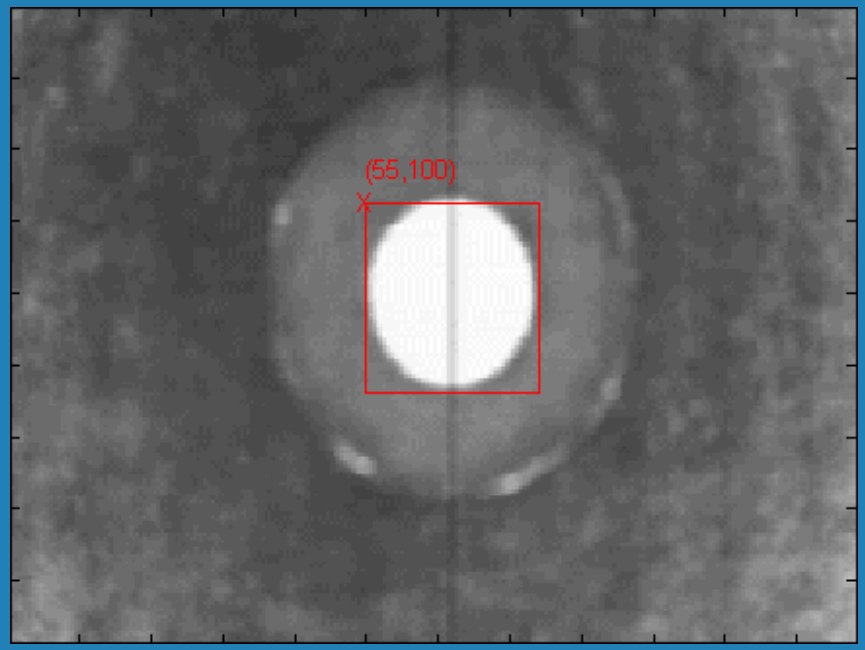
Correlation Map with Peak

Source Image, Found Rectangle, and Correlation Map

Data Set 2

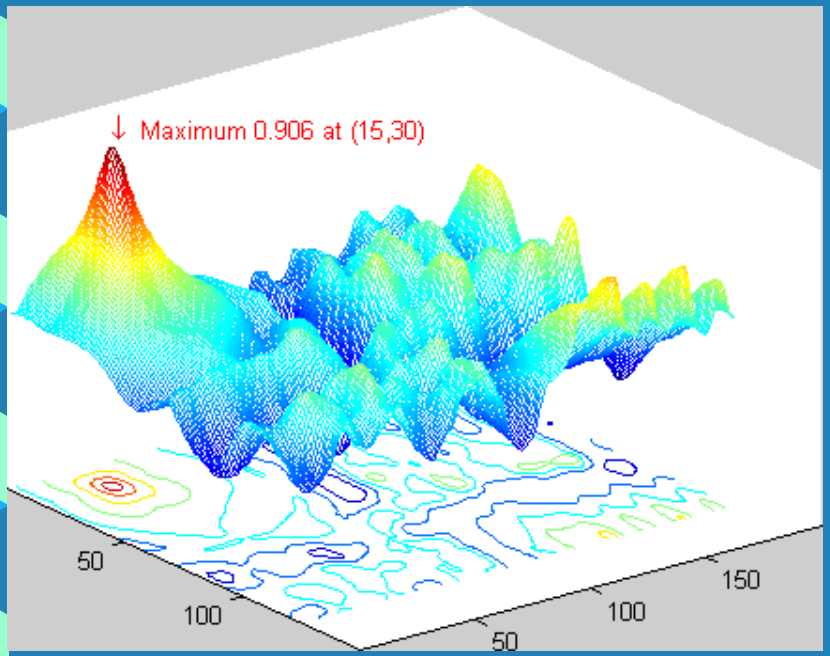


Correlation Map with Peak

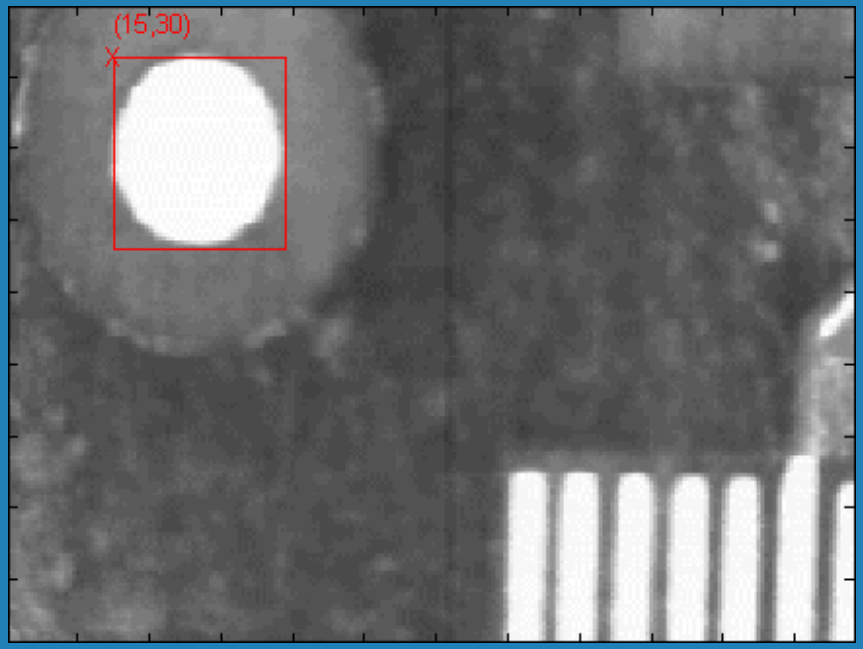


Source Image and Found Rectangle

Data Set 3

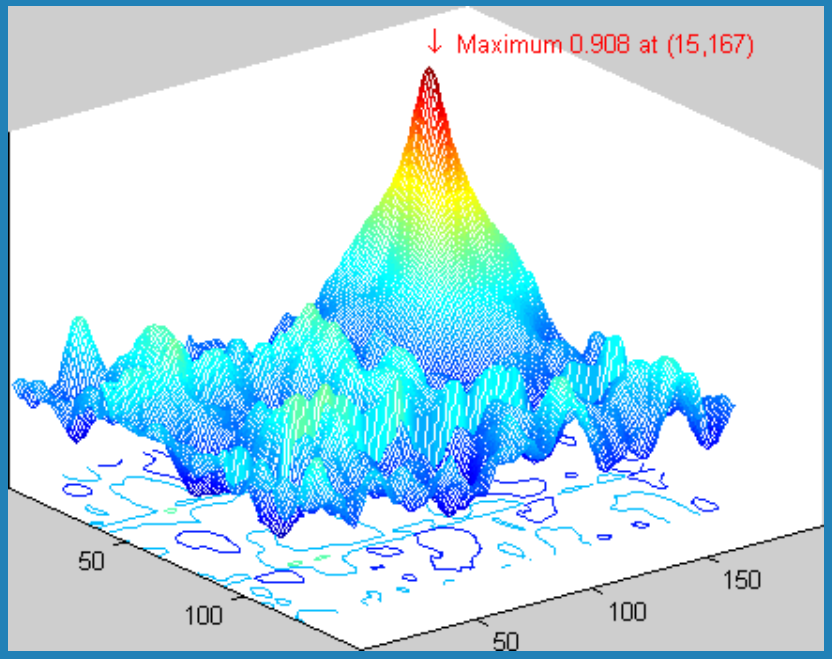


Correlation Map with Peak

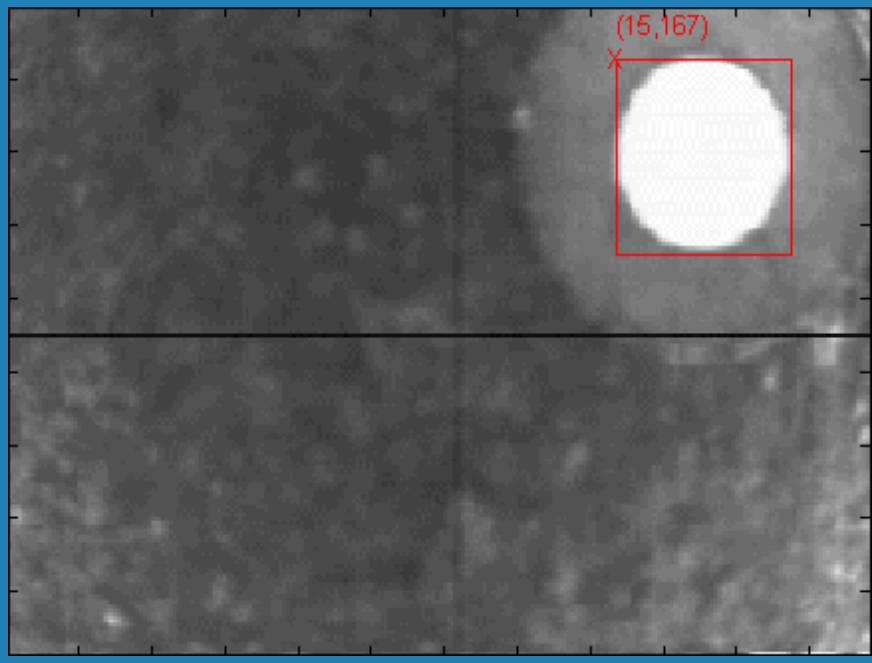


Source Image and Found Rectangle

Data Set 4

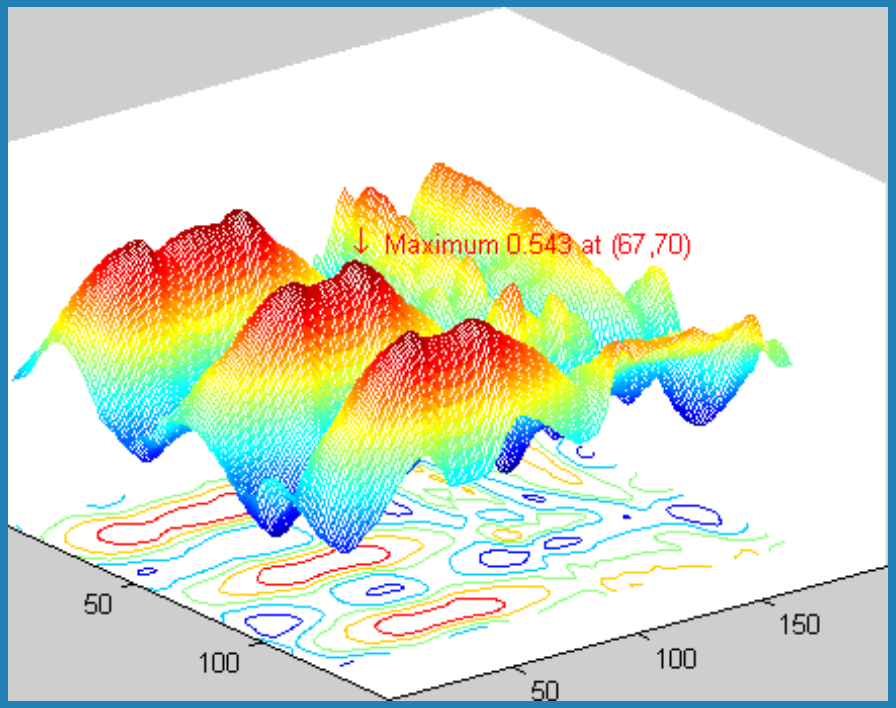


Correlation Map with Peak

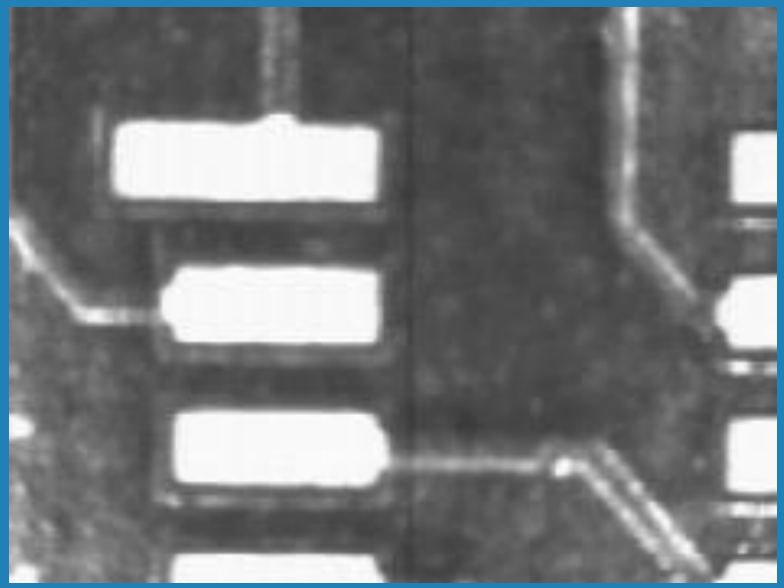


Source Image and Found Rectangle

Data Set 5, Corr. Map

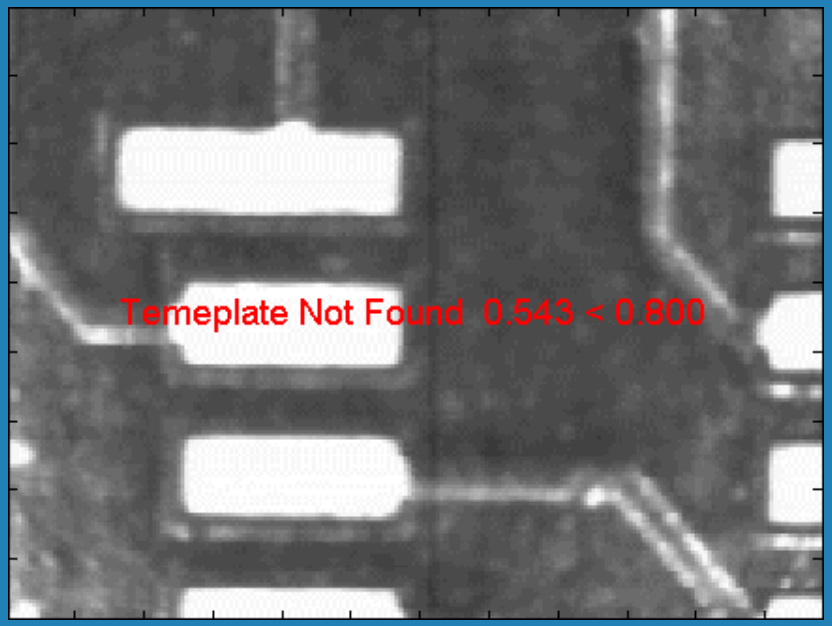


Correlation Map with Peak

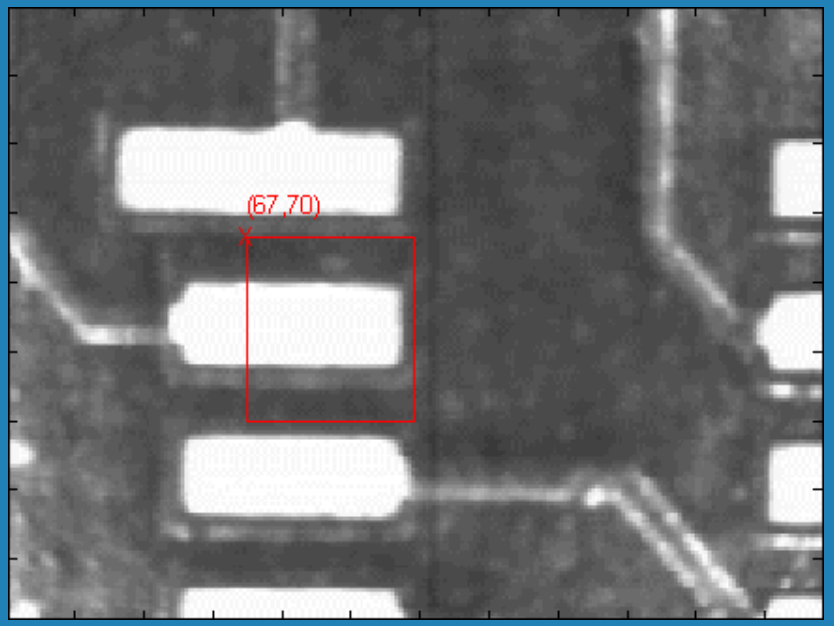


Source Image

Data Set 5, Results



Threshold set to 0.800



Threshold set to 0.200