



CPSC 425: Computer Vision



Image Credit: https://docs.adaptive-vision.com/4.7/studio/machine_vision_guide/TemplateMatching.html

Lecture 6: Template Matching

(unless otherwise stated slides are taken or adopted from **Bob Woodham, Jim Little** and **Fred Tung**)

Template Matching

How can we find a part of one image that matches another?

or,

How can we find instances of a pattern in an image?

Template Matching

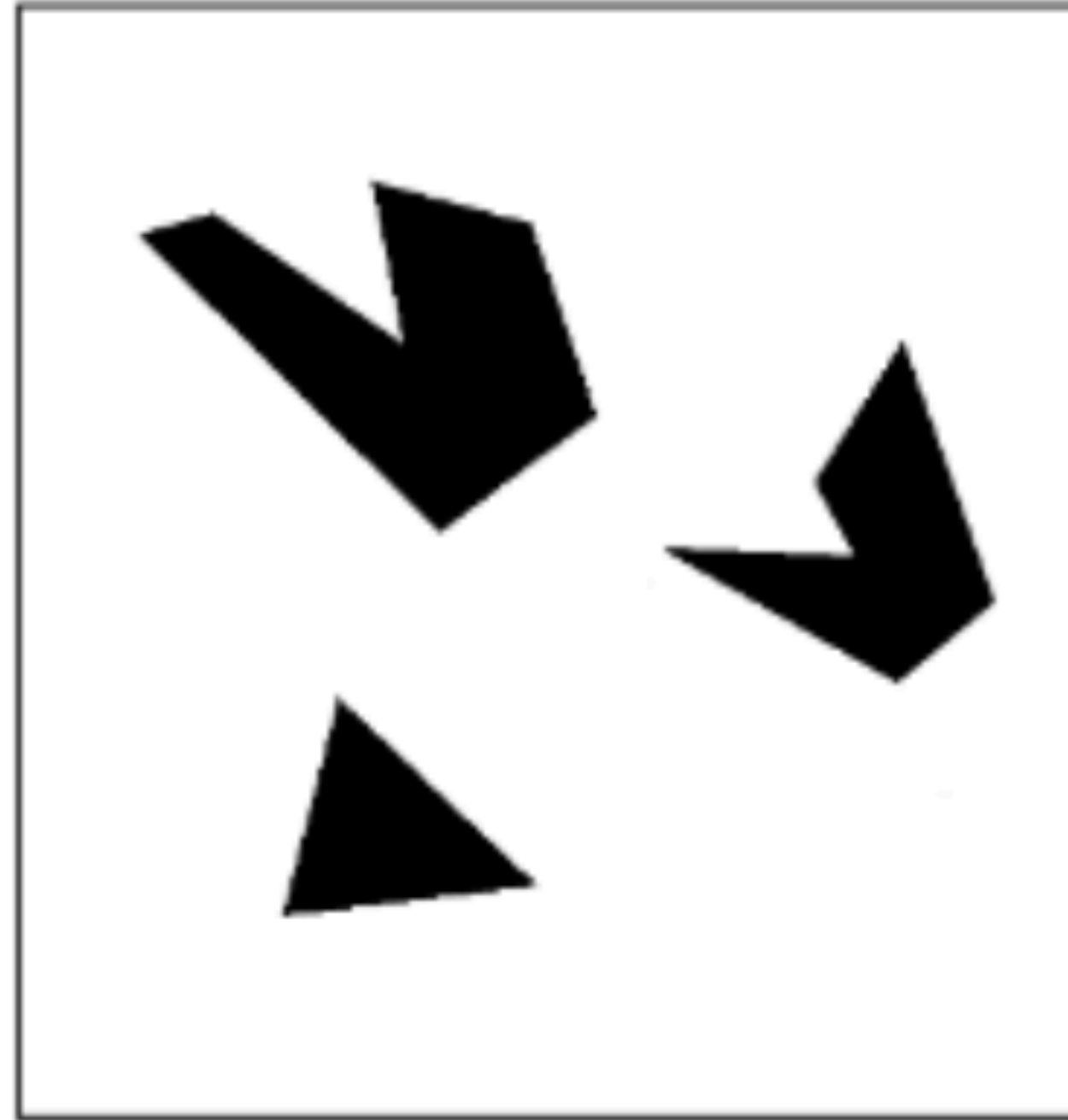
How can we find a part of one image that matches another?

or,

How can we find instances of a pattern in an image?

Key Idea: Use the pattern as a **template**

Template Matching



Scene



Template (mask)

A toy example

Template Matching

We can think of convolution/**correlation** as comparing a template (the filter) with each local image patch.

- Consider the filter and image patch as vectors.
- Applying a filter at an image location can be interpreted as computing the dot product between the filter and the local image patch.

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Template

0	0	0
0	1	0
0	1	1

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Image Patch 1

0	0	0
0	1	0
0	1	1

Image Patch 2

1	0	1
0	1	0
0	0	0

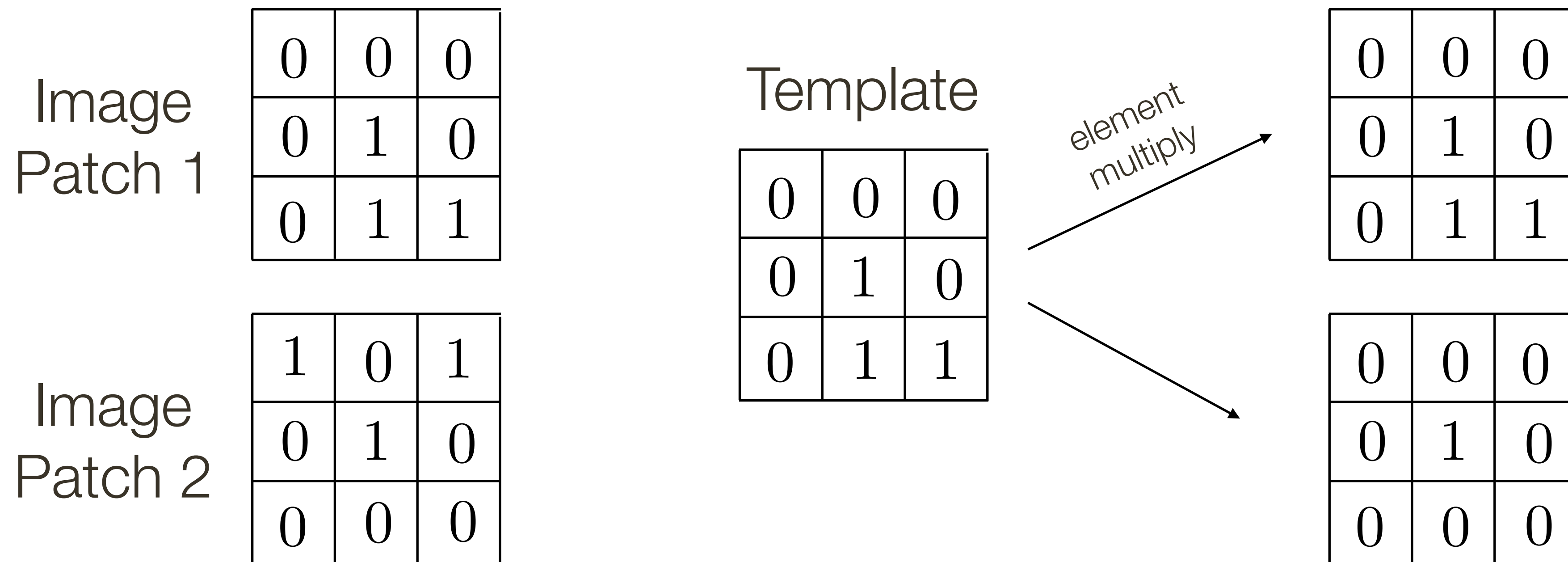
Template

0	0	0
0	1	0
0	1	1

Template Matching

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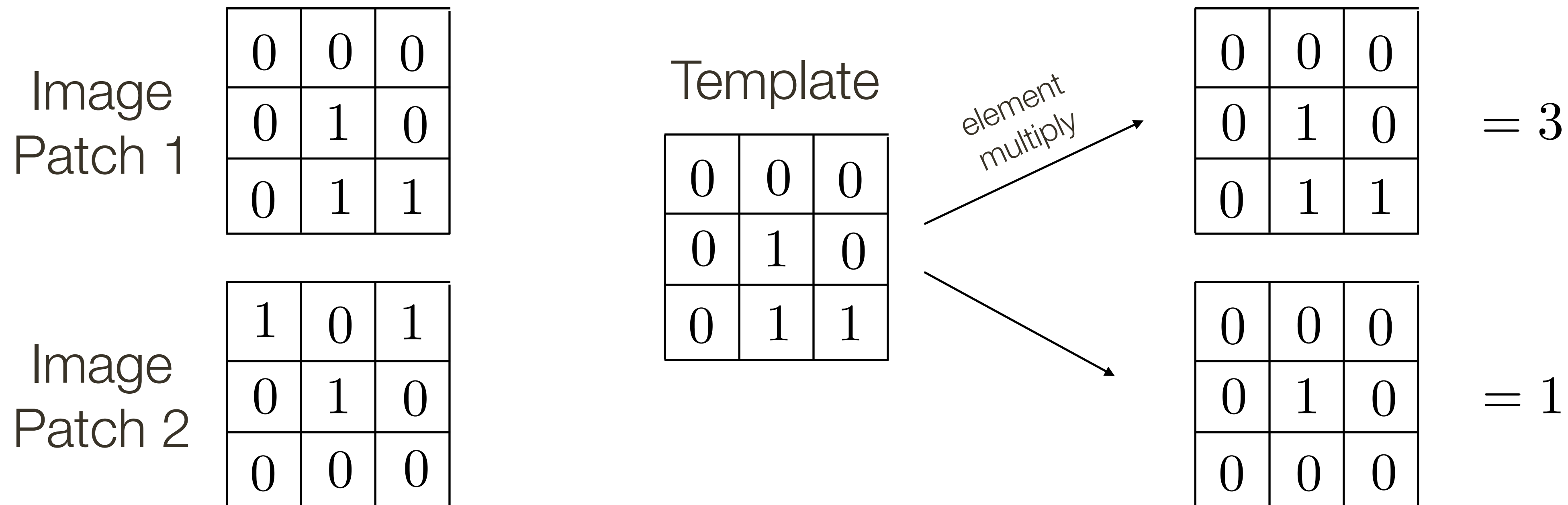
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Template Matching

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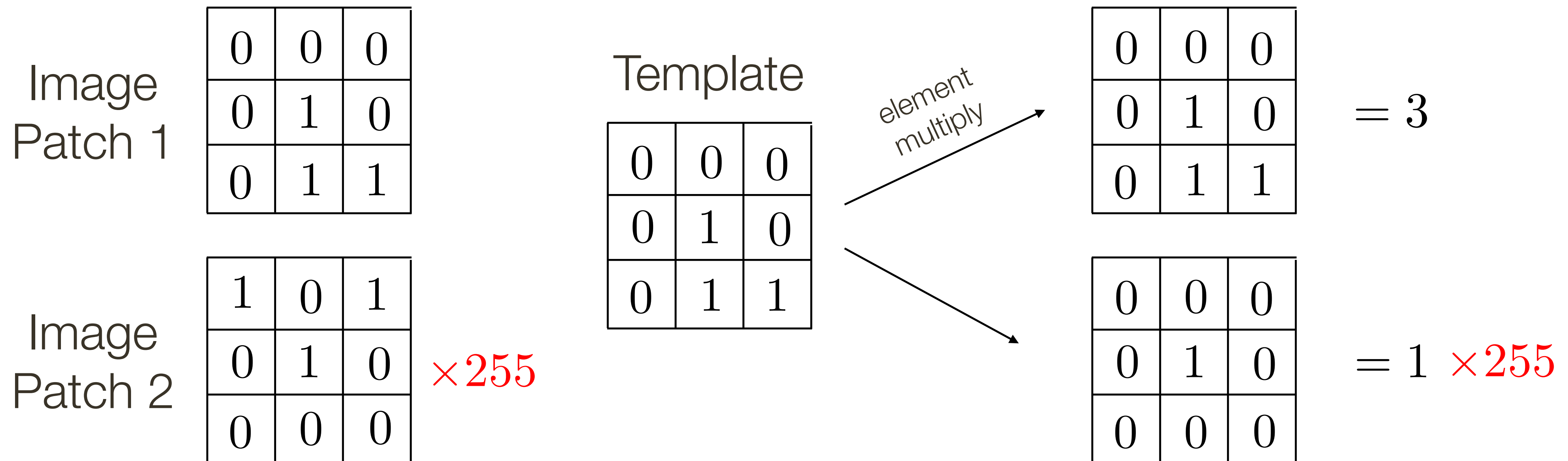
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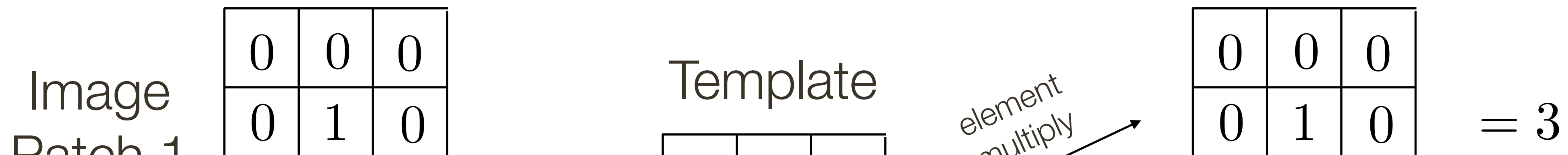
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Template Matching

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The dot product may be large simply because the image region is bright.

We need to normalize the result in some way.



Template Matching

Let a and b be vectors. Let θ be the angle between them. We know

$$\cos \theta = \frac{a \cdot b}{|a||b|} = \frac{a \cdot b}{\sqrt{(a \cdot a)(b \cdot b)}} = \frac{a}{|a|} \frac{b}{|b|}$$

where \cdot is dot product and $| |$ is vector magnitude

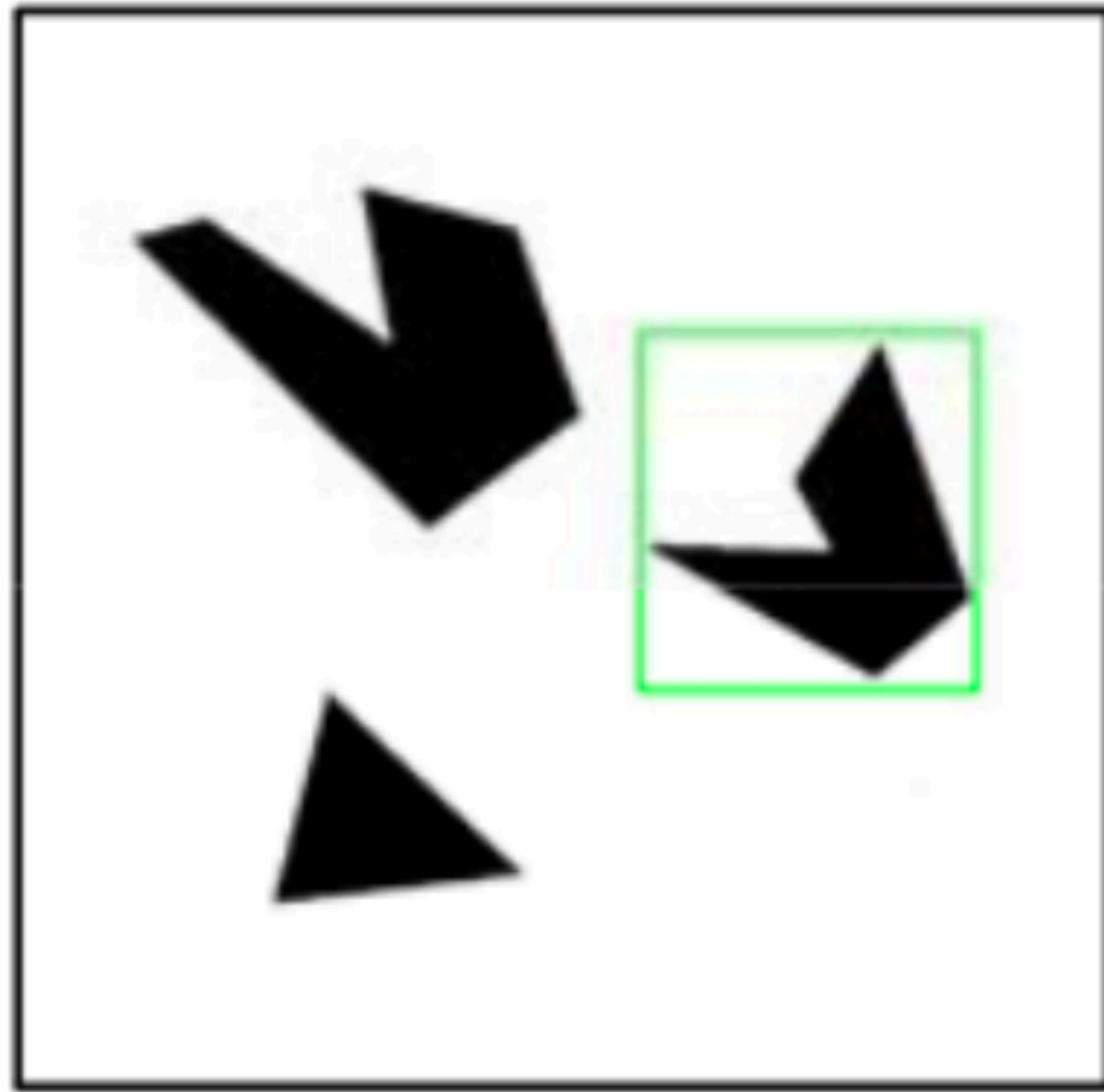
Correlation is a dot product

Correlation measures similarity between the filter and each local image region

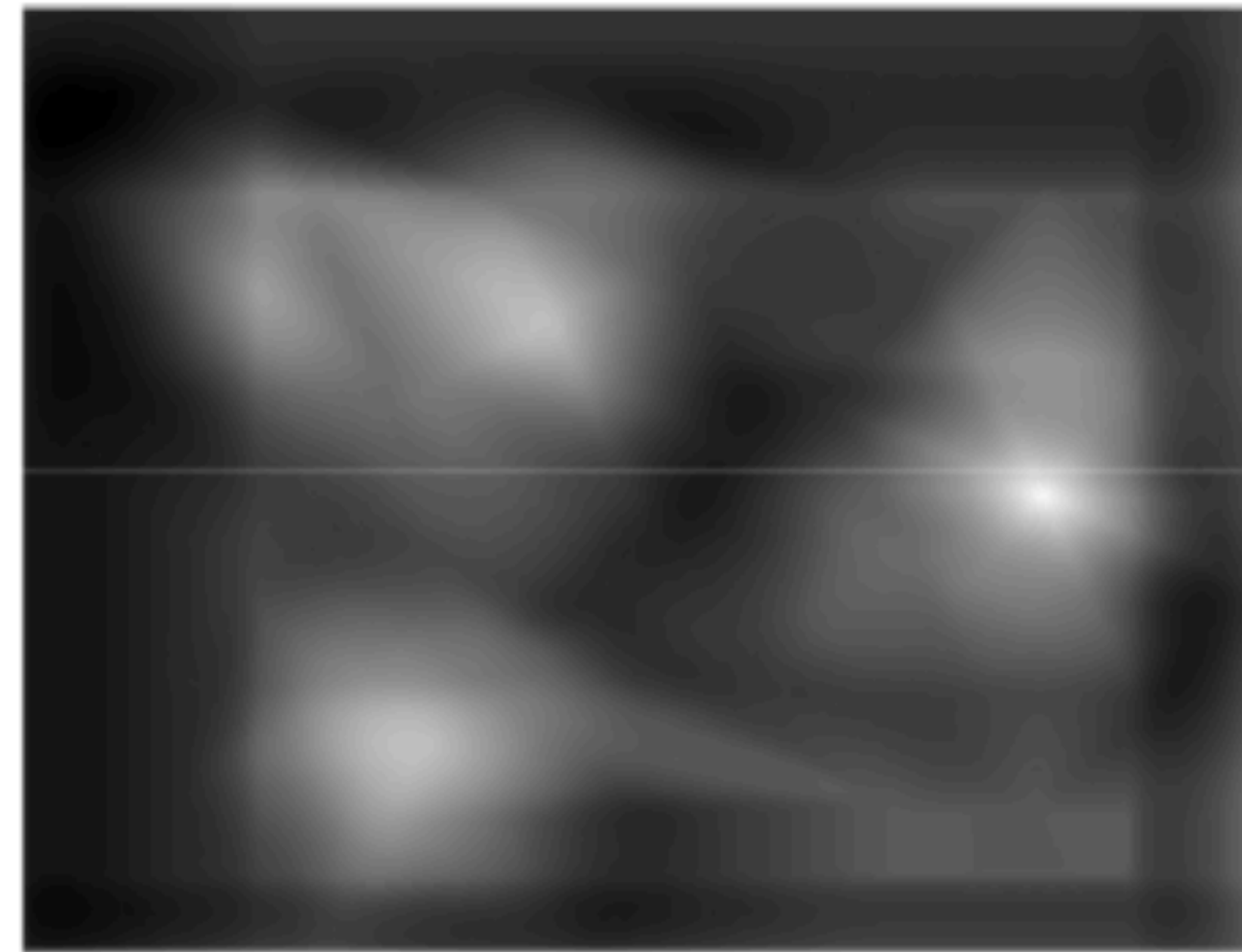
Normalized correlation varies between -1 and 1

Normalized correlation attains the value 1 when the filter and image region are identical (up to a scale factor)

Template Matching



Detected template



Correlation map

Template Matching

Linear filtering the entire image computes the entire set of dot products, one for each possible alignment of filter and image

Important Insight:

- filters look like the pattern they are intended to find
- filters find patterns they look like

Linear filtering is sometimes referred to as **template matching**