Image Processing
INT3404 20
Week 5: Spatial filtering (cont)

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Schedule

Tuần	Nội dung	Yêu cầu đối với sinh viên (ngoài việc đọc tài liệu tham khảo)
1	Giới thiệu môn học	Cài đặt môi trường: Python 3, OpenCV 3, Numpy, Jupyter Notebook
2	Ảnh số (Digital image) – Phép toán điểm (Point operations) Làm quen với OpenCV + Python Điều chỉnh độ tương phản (Contrast adjust)– Ghép ảnh (Combining images)	
3	Histogram - Histogram equalization	Làm bài tập 1: điều chỉnh gamma tìm contrast hợp lý
4	Phép lọc trong không gian điểm ảnh (linear processing filtering)	Thực hành ở nhà
5	Phép lọc trong không gian điểm ảnh (linear processing filtering) (cont.) Thực hành: Cách tìm filters	Thực hành ở nhà
6	Thực hành: Ứng dụng của histogram; Tìm ảnh mẫu (Template matching)	Bài tập mid-term
7	Trích rút đặc trưng của ảnh Cạnh (Edge) và đường (Line) và texture	Thực hành ở nhà
8	Các phép biến đổi hình thái (Morphological operations)	Làm bài tập 2: tìm barcode
9	Chuyển đổi không gian – Miền tần số – Phép lọc trên miền tần số Thông báo liên quan đồ án môn học	Đăng ký thực hiện đồ án môn học
10	Xử lý ảnh màu (Color digital image)	Làm bài tập 3: Chuyển đổi mô hình màu và thực hiện phân vùng
11	Các phép biến đổi hình học (Geometric transformations)	Thực hành ở nhà
12	Nhiễu – Mô hình nhiễu – Khôi phục ảnh (Noise and restoration)	Thực hành ở nhà
13	Nén ảnh (Compression)	Thực hành ở nhà
14	Hướng dẫn thực hiện đồ án môn học	Trình bày đồ án môn học
15	Hướng dẫn thực hiện đồ án môn học Tổng kết cuối kỳ	Trình bày đồ án môn học

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Recall week 5

- Filter design
- Edge-preserving smoothing filter
- Automatic filter learning with deep learning

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Week 6

- Template matching
- Filters & Histogram

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Template matching

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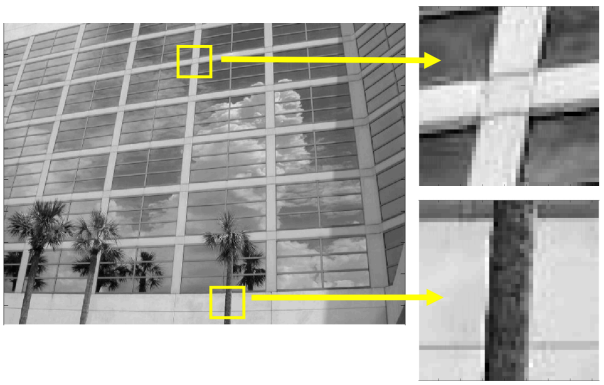
Template matching

- What if we cut little pictures out from an image, then tried to do cross correlation them with the same or other images?



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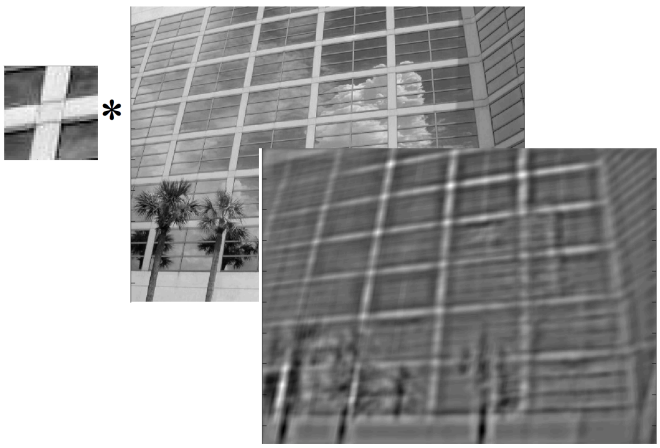
Template matching



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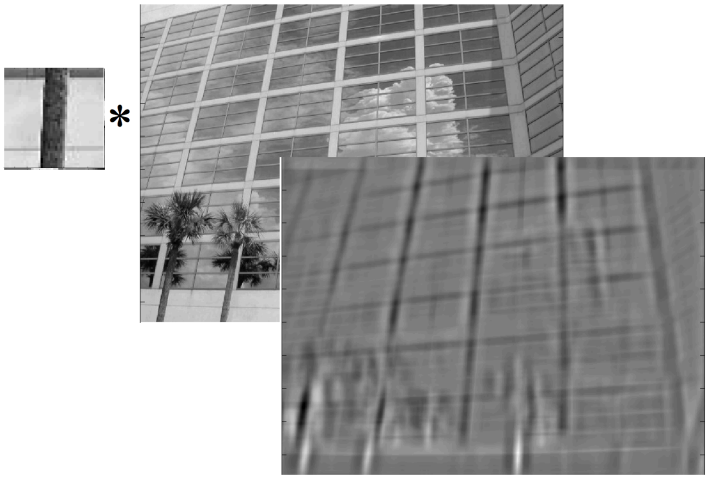
Template matching



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Actually...

I subtracted the mean gray value from both the image and the template before doing cross correlation.

Why?

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Problem with correlation of raw image template

Consider correlation of template with an image of constant grey value:

a	b	c
d	e	f
g	h	i

ⓧ

v	v	v
v	v	v
v	v	v

Result: v*(a+b+c+d+e+f+g+h+i)

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Problem with correlation of raw image template

Now consider correlation with a constant image that is twice as bright

a	b	c
d	e	f
g	h	i

ⓧ

2v	2v	2v
2v	2v	2v
2v	2v	2v

Result: $2*v*(a+b+c+d+e+f+g+h+i)$
$> v*(a+b+c+d+e+f+g+h+i)$

Larger score, regardless of what the template is!

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Solution

- Subtract off the mean value of the template
- In this way, the correlation score is higher only when darker parts of the template overlap darker parts of the image, and the brighter parts of the template overlap brighter parts of the image

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Correspondence problem

Finding corresponding feature across two or more views

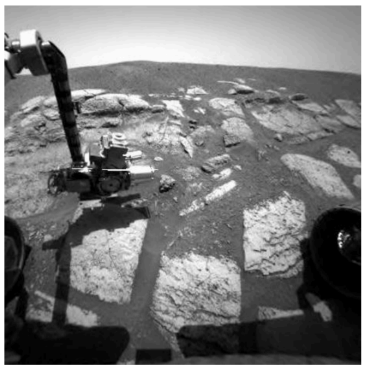

Image 1

Image 2

Note: this is a stereo pair from the NASA mars rover.
The rover is exploring the "El Capitan" formation

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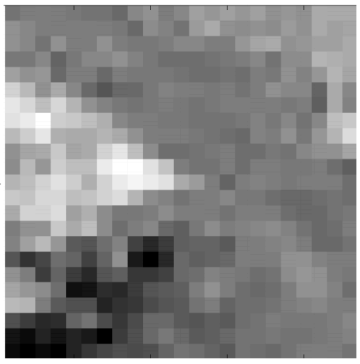
Example

Image 1



Template
(image patch)

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Example: Raw cross-correlation

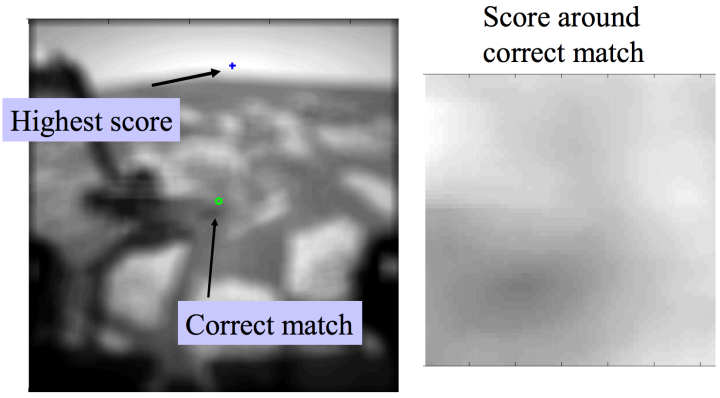

Image 2

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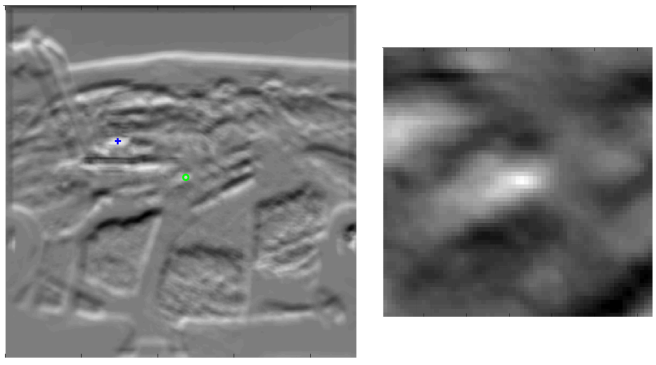
Example: Cross-correlation with zero-mean template



Better! But highest score is still not the correct match.
Note: highest score IS best within local neighborhood of correct match.

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"SSD" or "Block matching" (Sum of squared differences)

$$\sum_{[i,j]\in R} (f(i,j) - g(i,j))^2$$

1 – The most popular matching score
2 – T&V claim it works better than cross-correlation

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Relation between SSD and Correlation

$$SSD = \sum_{[i,j]\in R} (f-g)^2$$

$$= \sum_{[i,j]\in R} f^2 + \sum_{[i,j]\in R} g^2 - 2\sum_{[i,j]\in R} fg$$

$$C_{fg} = \sum_{[i,j]\in R} f(i,j)g(i,j)$$

Correlation!

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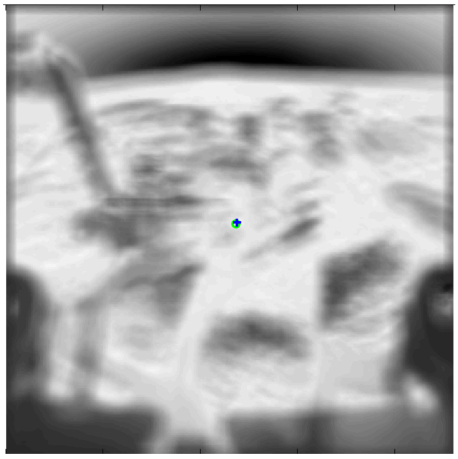
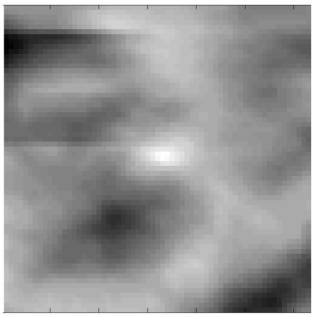
SSD





Best match (highest score) in image coincides with correct match in this case!

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Handling intensity changes

- the camera taking the second image might have different intensity response characteristics than the camera taking the first image
- Illumination in the scene could change
- The camera might have auto-gain control set, so that it's response changes as it moves through the scene.

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Intensity normalization

- When a scene is imaged by different sensors, or under different illumination intensities, both the SSD and the C_{fg} can be large for windows representing the same area in the scene!
- A solution is to NORMALIZE the pixels in the windows before comparing them by subtracting the mean of the patch intensities and dividing by the std.dev.

$$\hat{f} = \frac{f - \bar{f}}{\sqrt{\sum (f - \bar{f})^2}} \qquad \hat{g} = \frac{g - \bar{g}}{\sqrt{\sum (g - \bar{g})^2}}$$

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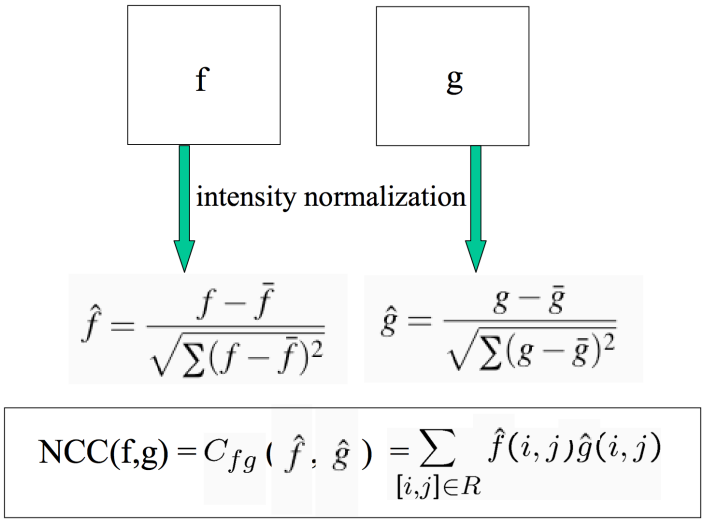
Normalized cross correlation



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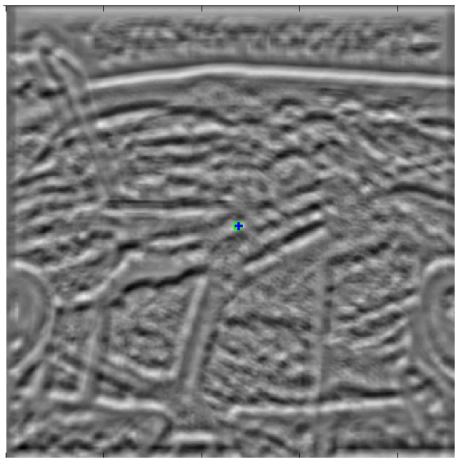
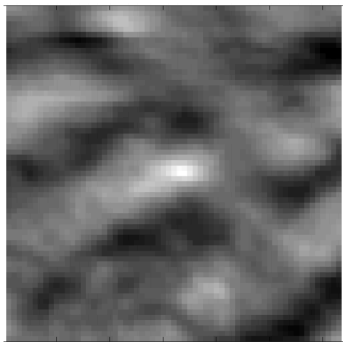
Normalized cross correlation





Highest score also coincides with correct match.
Also, looks like less chances of getting a wrong match.

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Normalized cross correlation

- Important point about NCC:
  - Score values range from 1 (perfect match) to -1 (completely anti-correlated)

- Intuition: treating the normalized patches as vectors, we see they are unit vectors. Therefore, correlation becomes dot product of unit vectors, and thus must range between -1 and 1

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Midterm announcement

- Problem:
  - How to deal with distortion when doing template matching?
- What to do:
  - Find/Invent a method → do a small research
  - Implement it (Python)
- Scoring:
  - Method explanation: 80%
  - Implementation: 20% → generate your own data (target and template images)
- Due: 2 weeks
- Submission: a pdf + source code

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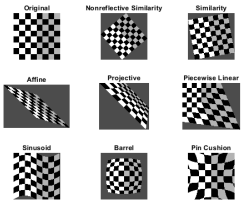
Example of "distortion"

Change of perspective

Change of appearance by time

Geometric transformed



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