Feature Descriptors
16-385 Computer Vision (Kris Kitani)
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Tiny Images
Just downsample it
Simple
Fast
Robust to small affine transformation

What are the problems?
Multi-Scale Oriented Patches (MOPS)

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Given a feature \((x, y, s, \theta)\)

Get 40 x 40 image patch, subsample every 5th pixel

(what’s the purpose of this step?)

Subtract the mean, divide by standard deviation

(what’s the purpose of this step?)

Haar Wavelet Transform

(what’s the purpose of this step?)
Given a feature \((x, y, s, \theta)\)

Get 40 x 40 image patch, subsample every 5th pixel (low frequency filtering, absorbs localization errors)

Subtract the mean, divide by standard deviation (what's the purpose of this step?)

Haar Wavelet Transform (what's the purpose of this step?)
Given a feature \((x, y, s, \theta)\)

Get 40 x 40 image patch, subsample every 5th pixel (low frequency filtering, absorbs localization errors)

Subtract the mean, divide by standard deviation (removes bias and gain)

Haar Wavelet Transform (\textit{what's the purpose of this step?})
Multi-Scale Oriented Patches (MOPS)


Given a feature \((x, y, s, \theta)\)

Get 40 x 40 image patch, subsample every 5th pixel (low frequency filtering, absorbs localization errors)

Subtract the mean, divide by standard deviation (removes bias and gain)

Haar Wavelet Transform (low frequency projection)
Haar Wavelets
(actually, Haar-like features)

Use responses of a bank of filters as a descriptor
Haar wavelet responses can be computed with filtering efficiently in constant time with integral images.

Haar wavelet responses can be computed efficiently (in constant time) with integral images.
### Integral Image

Original image:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Integral image:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>12</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

The integral image can be computed as:

\[
A(x, y) = \sum_{x' \leq x, y' \leq y} I(x', y')
\]
Integral Image

\[
A(x, y) = \sum_{x' \leq x, y' \leq y} I(x', y')
\]

Can find the **sum** of any block using **3** operations

\[
A(x_1, y_1, x_2, y_2) = A(x_2, y_2) - A(x_1, y_2) - A(x_2, y_1) + A(x_1, y_1)
\]
What is the sum of the bottom right 2x2 square?

\[
A(x_1, y_1, x_2, y_2) = A(x_2, y_2) - A(x_1, y_2) - A(x_2, y_1) + A(x_1, y_1)
\]

\[
A(1, 1, 3, 3) = A(3, 3) - A(1, 3) - A(3, 1) + A(1, 1)
\]

\[
= 19 - 8 - 5 + 1
\]

\[
= 7
\]
Given an image patch, compute filter responses

filter bank (20 Haar wavelet filters)

Responses are usually computed at specified location as a face patch descriptor
Given an image patch, compute filter responses

filter bank (20 Haar wavelet filters)

Responses are usually computed at specified location as a face patch descriptor

When will this feature descriptor fail?
Anti Face
This face is unrecognizable to several state-of-art face detection algorithms.

Face
Once computer vision programs detect a face, they can extract data about your emotions, age, and identity.
See how a face is detected

Camouflage from face detection.

CV Dazzle explores how fashion can be used as camouflage from face-detection technology, the first step in automated face recognition.

From all appearances, deception has always been critical to daily survival—for human and non-human creatures alike—and,