Announcement

• Arijit’s office hours will be in 1122 AV Williams

Sampling and Multiscale
Why Multiscale

• To look at images at different sizes.
• To analyze images at different scales.
  – Eg., key points (such as blobs) might exist at different scales.
  – Eg., video with large motion will have small motion at after we shrink images.
• Efficiency; fewer operations needed for small image.

Sampling

• How do we shrink an image?
• First idea, sample the pixels.
  – Eg., take only pixels in odd columns and rows.
• Problem, aliasing
Aliasing Example
Aliasing: Disintegrating Texture

- The checkers on a plane should become smaller with distance.
- But aliasing causes them to become larger and/or irregular.
- Increasing resolution only moves the artefact closer to the horizon.

Temporal Aliasing

The wheel appears to be moving backwards at about ¼ angular frequency:
http://lite.bu.edu/lite1/perception/anamorphic/wade.html
So, what’s going on?

- The image (scene) is changing faster than the sampling rate.
  - Eg., sharp changes on the scale of one pixel.
- When we drop pixels, we arbitrarily capture or miss these changes.
- Solution?
  - We cannot capture patterns that change quickly.
  - Best to eliminate them before sampling.
  - We must lose small scale details, but at least they don’t interfere with other patterns.

Example

- Right: When the image changes slowly, sampling can capture these changes.
- Left: When the image changes quickly, these rapid changes masquerade as some slow change that doesn’t really exist.
- We’d be better off getting rid of rapid changes on left, and having a constant image.
Eliminate small scale with blurring

• After blurring, things don’t change quickly.

Example

Sample ->

Or
Example cont’d

Efficiency

• Intuition: If we want to smooth a lot, we can smooth a little, shrink, and then smooth more.
  – Smoothing gets rid of rapid changes, so information isn’t lost by sampling.
  – Sampling can reintroduce rapid changes.

• Box Filter
  – Smoothing with a 2x2 box filter and subsampling means replacing each pixel with the average in a 2x2 window.
  – Repeating this means averaging a 4x4 window.
  – If we smooth with 4x4 box, 16 operations per pixel (16N).
  – This way: \(4N + 4(N/4) + 4(N/16) + \ldots\)

• Same qualitative behavior works with Gaussian smoothing.
The Gaussian Pyramid

\[ G_4 = (G_3 \ast \text{gaussian}) \downarrow 2 \]
\[ G_3 = (G_2 \ast \text{blur}) \downarrow 2 \]
\[ G_2 = (G_1 \ast \text{gaussian}) \downarrow 2 \]
\[ G_1 = (G_0 \ast \text{blur}) \downarrow 2 \]
\[ G_0 = \text{Image} \]

(Weizmann Institute Vision Class)