Announcement

- Arijit's office hours will be in 1122 AV Williams

Sampling and Multiscale

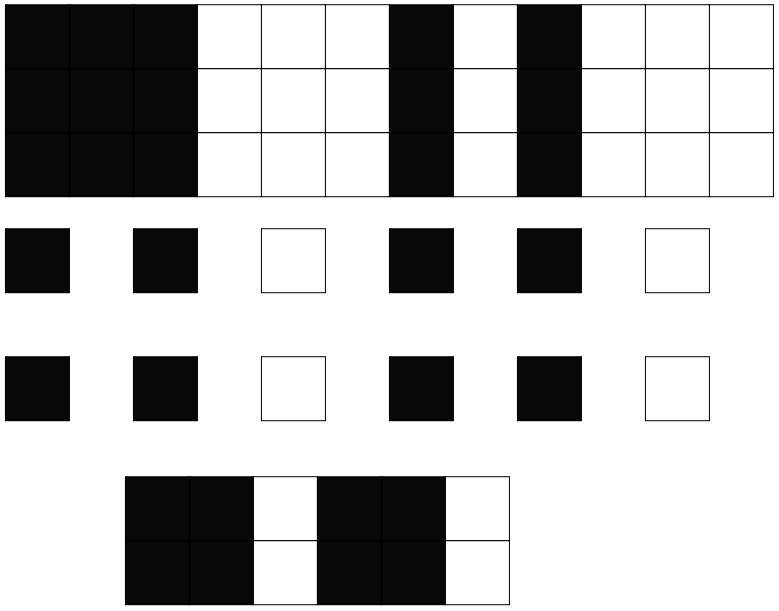
Why Multiscale

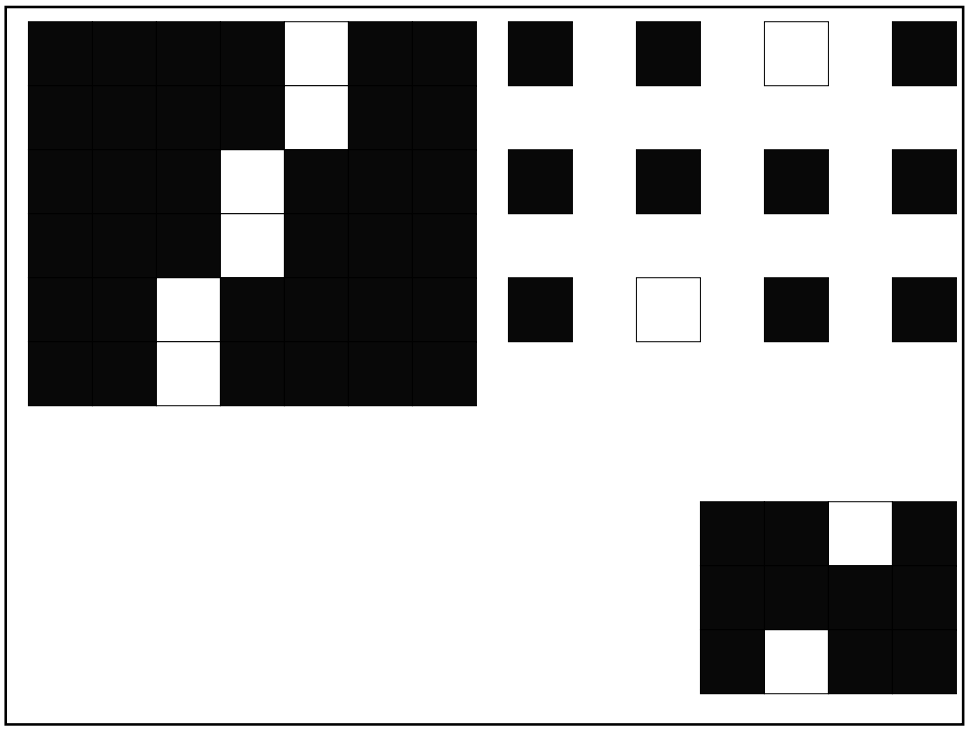
- To look at images at different sizes.
- To analyze images at different scales.
  - Eg., key points (such as blobs) might exist at different scales.
  - Eg., video with large motion will have small motion at after we shrink images.
- Efficiency; fewer operations needed for small image.

Sampling

- How do we shrink an image?
- First idea, sample the pixels.
  - Eg., take only pixels in odd columns and rows.
- Problem, aliasing

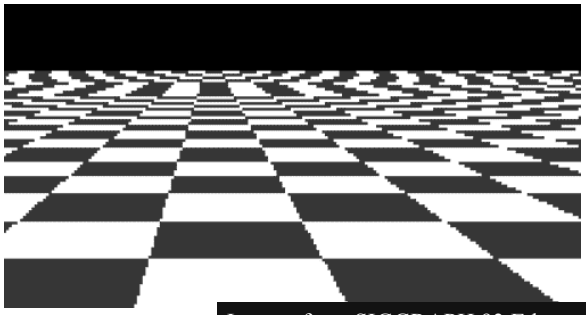
Aliasing Example





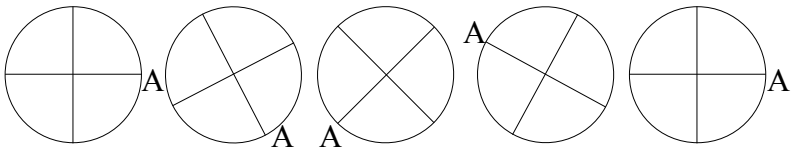
Aliasing: Disintegrating Texture

- 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.



Images from SIGGRAPH 93 Educators' Slide Set

Temporal Aliasing

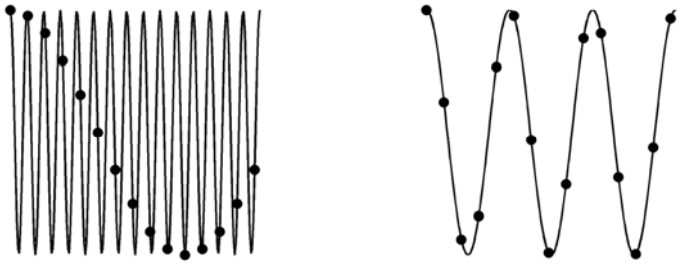


The wheel appears to be moving backwards at about ¼ angular frequency:
http://lite.bu.edu/lite1/perception/anamorphic/wade.html

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.

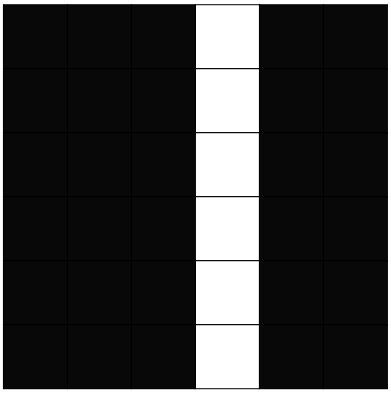
• Left: When the image changes quickly, these rapid changes masquerade as some slow change that doesn't really exist.

•We'd be better off getting rid of rapid changes on left, and having a constant image.

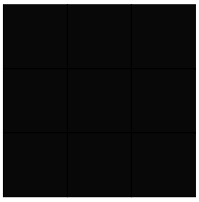
Eliminate small scale with blurring

- After blurring, things don't change quickly.

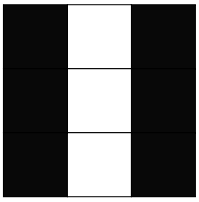
Example



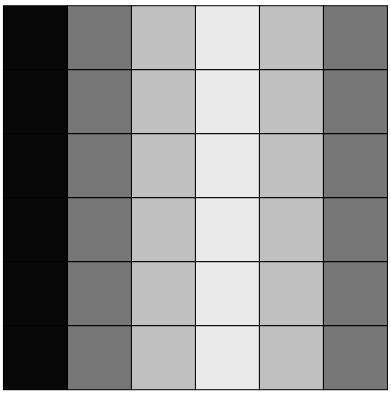
Sample ->

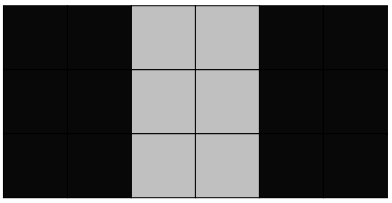


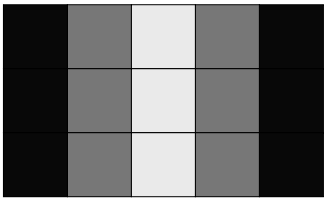
Or



Example cont'd



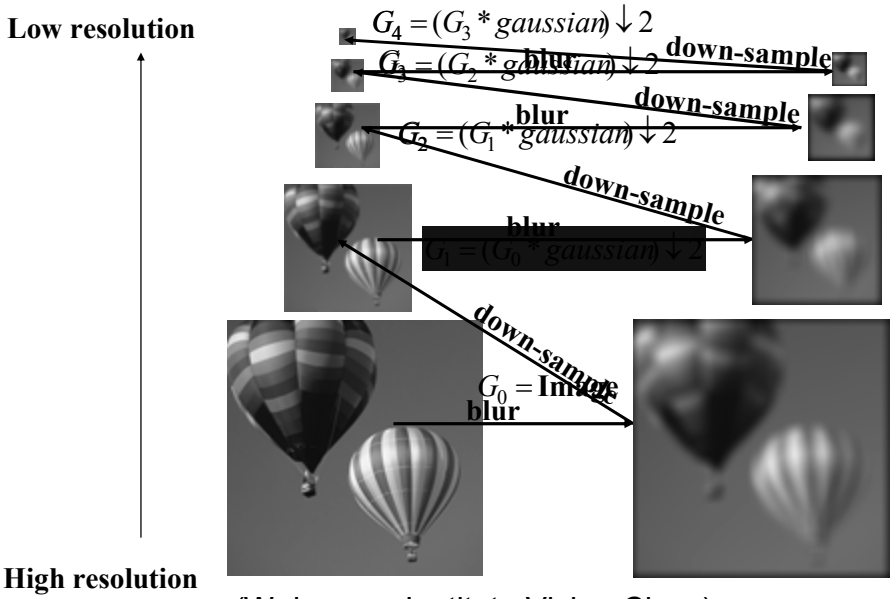




Efficiency

- 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) + …
- Same qualitative behavior works with Gaussian smoothing.

The Gaussian Pyramid



(Weizmann Institute Vision Class)