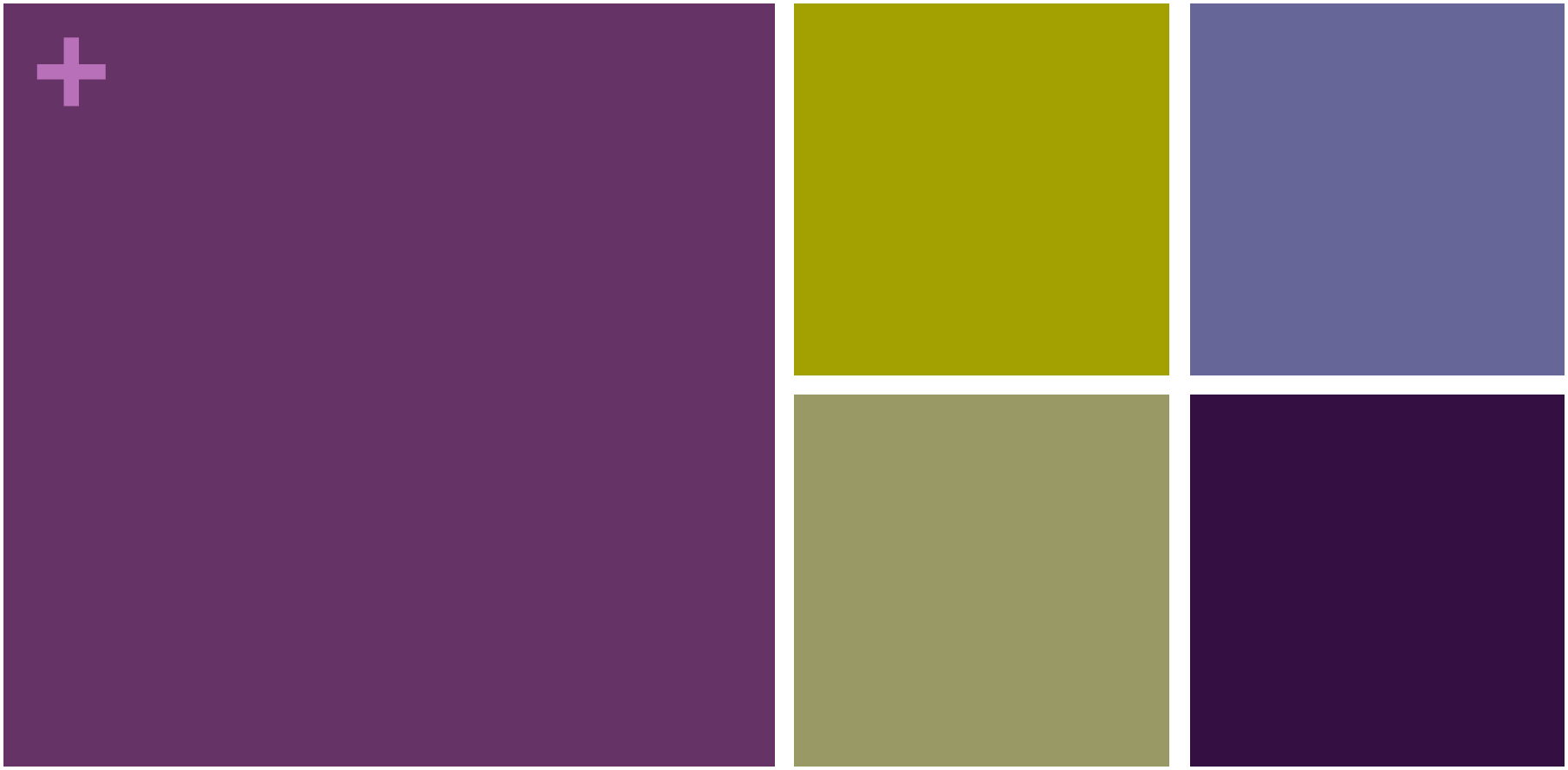


CPCS391 Computer Graphics 1
Lecture 4: Anti-aliasing

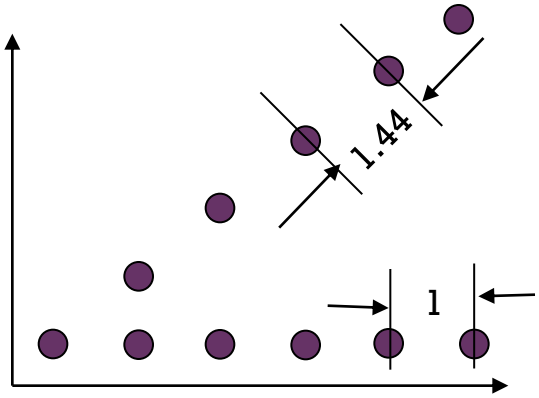
Instructor: Dr. Sahar Shabanah

Side Effects of Scan Conversion

- The most common side effects when working with raster devices are:
  - Unequal intensity
  - Overstrike
  - Aliasing

Unequal Intensity

- Human perception of light is dependent on
  - Density and Intensity of light source.
- Thus, on a raster display with perfect squareness, a diagonal line of pixels will appear dimmer that a horizontal or vertical line.
- **Solution:**
  - By increasing the number of pixels on diagonal lines.



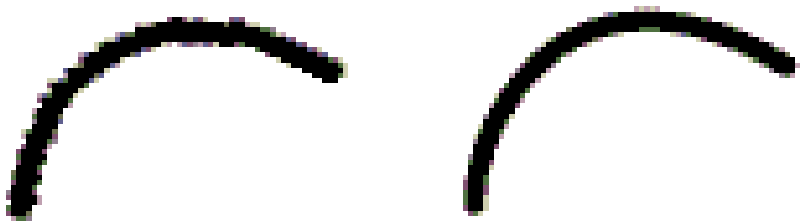
Overstrike

- The same pixel is written more than once.
- This results in intensified pixels in case of photographic media, such as slide or transparency
- **Solution**
  - Check each pixel to see whether it has already been written to prior to writing a new point.

Aliasing

- The effect created when rasterization is performed over a discrete series of pixels.
- In particular, when lines or edges do not necessarily align directly with a row or column of pixels, that line may appear unsmooth and have a stair-step edge appearance.
- jagged appearance of curves or diagonal lines on a display screen, which is caused by low screen resolution.
- Refers to the plotting of a point in a location other than its true location in order to fit the point into the raster.
- Consider equation $y = mx + b$
  - For $m = 0.5$, $b = 1$ and $x = 3$: $y = 2.5$
  - So the point (3,2.5) is plotted at alias location (3,3)

Anti-Aliasing



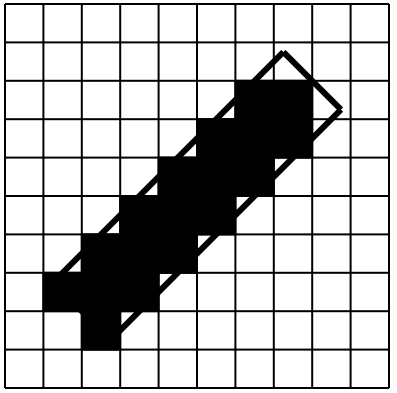
The image on the right shows the result of anti-aliasing through the use of higher resolution

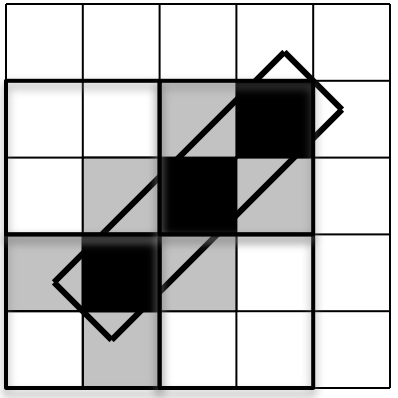
Anti-Aliasing

- Antialiasing utilizes blending techniques to blur the edges of the lines and provide the viewer with the illusion of a smoother line.
- Two general approaches:
- **Super-sampling**
  - samples at higher resolution, then filters down the resulting image
  - Sometimes called post-filtering
  - The prevalent form of anti-aliasing in hardware
- **Area sampling**
  - sample primitives with a box (or Gaussian, or whatever) rather than spikes
  - Requires primitives that have area (lines with width)
  - Sometimes referred to as pre-filtering

Super-sampling

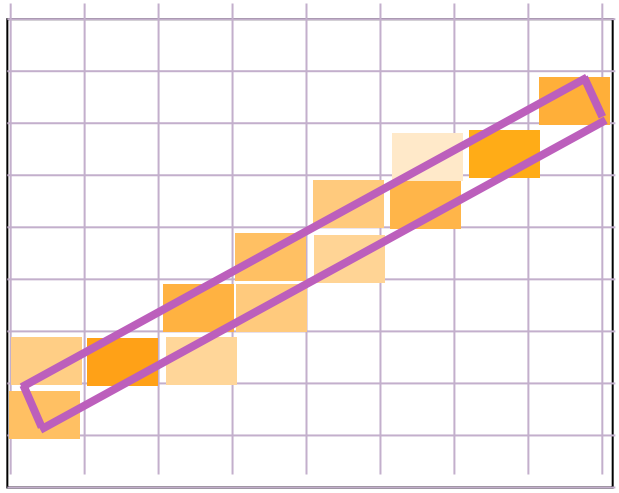
- Sample at a higher resolution than required for display, and filter image down
- 4 to 16 samples per pixel is typical
- Samples might be on a uniform grid, or randomly positioned, or other variants
- Divide each pixel into sub-pixels.
- The number of intensities are the max number of sub-pixels selected on the line segment within a pixel.
- The intensity level for each pixel is proportional to the number of sub-pixels inside the polygon representing the line area.
- Line intensity is distributed over more pixels.





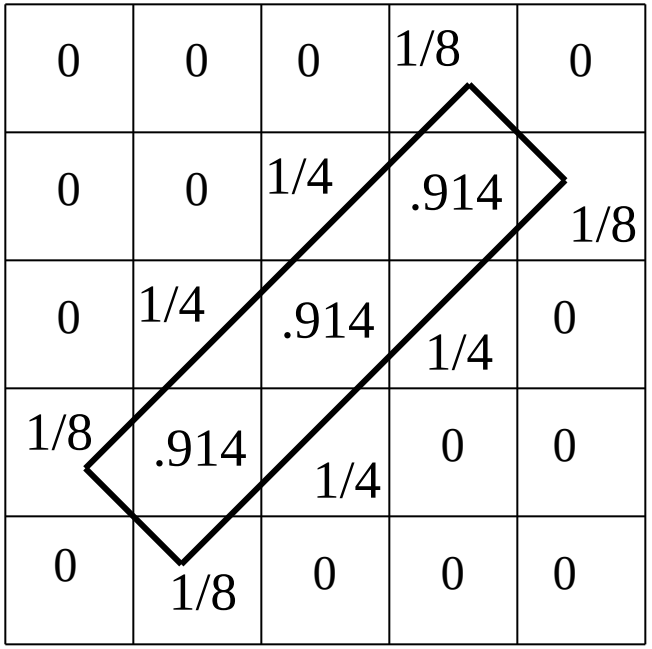
Area Sampling

- determine the percentage of area coverage for a screen pixel, then set the pixel intensity proportional to this percentage.
- Consider a line as having thickness
- Consider pixels as little squares
- **Unweighted area sampling**
  - Fill pixels according to the proportion of their square covered by the line
- **Weighed area sampling**
  - weight the contribution according to where in the square the primitive falls



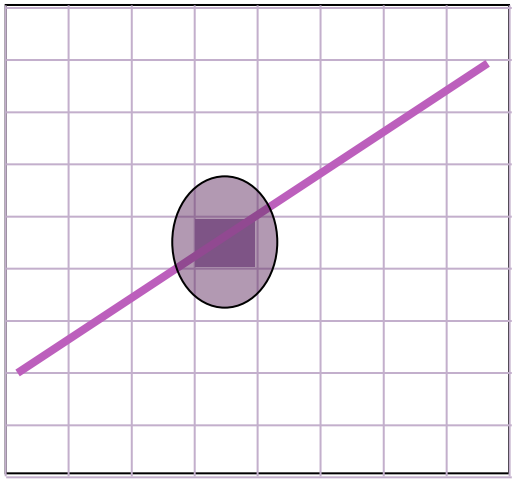
Unweighted Area Sampling

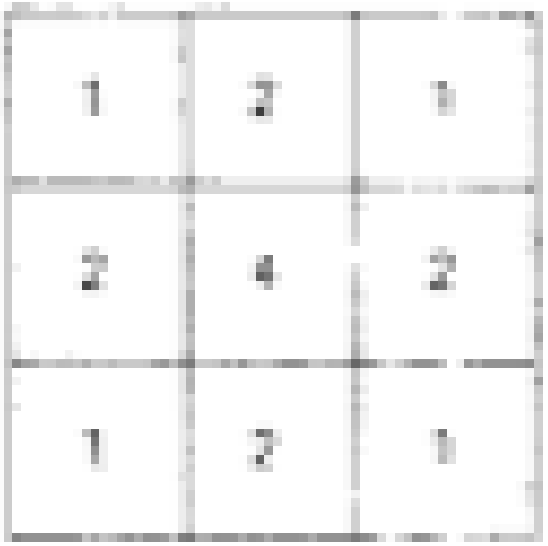
- primitive cannot affect intensity of pixel if it does not intersect the pixel
- equal areas cause equal intensity, regardless of distance from pixel center to area
- Un-weighted sampling colors two pixels identically when the primitive cuts the same area through the two pixels
- intuitively, pixel cut through the center should be more heavily weighted than one cut along corner



Weighted Area Sampling

- weight the subpixel contributions according to position, giving higher weights to the central subpixels.
- weighting function, W(x,y)
  - specifies the contribution of primitive passing through the point (x, y) from pixel center





Filtering Techniques

- a continuous weighting surface, (or filter function) covering the pixel
- applying the filter function by integrating over the pixel surface to obtain the weighted average intensity
- Weighting (Filter) Function
  - Determines the influence on the intensity of a pixel of a given small area dA of a primitive.
  - This function is constant for unweighted and decreases with increasing distance for weighted.
  - Total intensity is the integral of the weighting (filter) function over the area of overlap.
  - Ws is the volume (always between 0 and 1)
  - I=Imax •Ws
- Box, Cone and Gaussiean