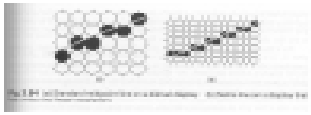
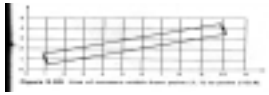
Aliasing and Antialiasing

- *Aliasing:* name given to jagged effect of lines
  - name comes from signal processing (see FvD Ch 14)
- Jagged effect caused by finite size of pixels
  - when change rows get step
- Increase resolution steps (jaggies) get less steep
  - double resolution -> quadruple memory, bandwidth, and scan-conversion time



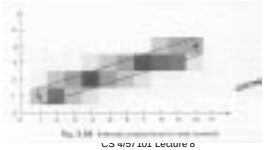
Unweighted Area Sampling

- Assume background white - lines black
- Recognize that primitive has non-zero width
  - even thinnest line is 1 pixel thick
- Consider line as (thin) rectangle
  - covers different (square) pixels to different extent
- In most cases should not set a single pixel to black
  - Set intensity of pixel differently for each pixel covered
  - Only horizontal and vertical lines effect only 1 pixel per row



Unweighted Area Sampling

- Simplest assumption on geometry of pixels
  - nonoverlapping square tiles - grey scale display
  - line contributes to intensity proportional to area of pixel's tile covered
  - pixel (2,1) is 70% black, (2,2) is 25% black
  - makes line appear better at a distance



Properties of Unweighted Area Sampling

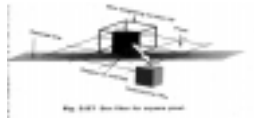
- 1. Intensity decreases with increasing distance from pixel to edge
- 2. Primitives do not influence pixel they do not intersect
- 3. Equal areas contribute equal intensity
  - distance from pixel center to area overlapped
  - small area in corner contributes same as equal-sized area in center

Weighted Area Sampling

- Change third property of *Unweighted Area Sampling*
  - areas closer to the pixel center contribute more
- Need to change "geometry" of pixel to preserve 2nd property
  - pixel is circle larger than square
  - if line intersects circle it contributes
- Terms *weighted* and *unweighted* come from idea of *weighting function* that determines effect of area dA on intensity of pixel

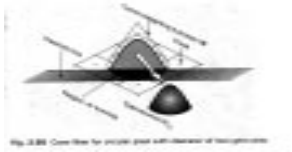
Weighting Function: Unweighted Area Sampling

- *Weighting Function W(x,y)*
  - height at (x,y) gives weight for area dA at (x,y)
  - unweighted - graph of *W* is box i.e. weight is constant
  - Intensity is $I_{max} \int_{\text{Area of overlap}} W(x,y)\, dA = I_{max} W_s$ where W_s is area of wedge



Weighting Function: Weighted Area Sampling

- *Weighting Function W(x,y)*
  - choose simplest graph with height proportional to distance
  - graph of *W* is circular cone
  - choose radius as distance between pixel centers



Consequences of Weighting

- Pixels covered by line of width one not so bright
  - not all *support* of weighting function covered
- Pixels that would not have received contribution do
- Pixel can have intensity I_{max} if line is wide enough to cover support of *W*
- Contrast is decreased
- Even horizontal and vertical lines influence more than 1 pixel per row
- Why rotational symmetry?
  - Simpler: calculation don't depend on angle of line
  - Theoretically optimum

Gupta-Sproull Antialiasing

- Precomputes the subvolume of a normalized filter function and stores them in a table
- Make pixel support circle of radius 1
- Line of units thickness intersects between 2 and 5 supports in a column, typically 3
- Original table gives for 4 bit display
- More bits - more accuracy required in distance

Gupta-Sproull Antialiasing

- Can modify Bressenham's Algorithm
  - Still choose between E and NE pixels
  - Now need to set intensity of pixel and 2 nearest neighbors
  - can formulate as incremental algorithm
  - Other issues:
    - need to antialiase the end points seperately
    - lookup table applies only to line of one thickness
    - more general discussion Foley & van Dam Ch. 19.3
    - Characters: can filter 19.4 or manually soften