CSE 321

Aliasing and Anti-Aliasing Techniques

What is Aliasing?

- Scan conversion is essentially a systematic approach to mapping objects that are denned in continuous space to their discrete approximation.
- The various forms of distortion that result from this operation are collectively referred to as the aliasing effects of scan conversion.

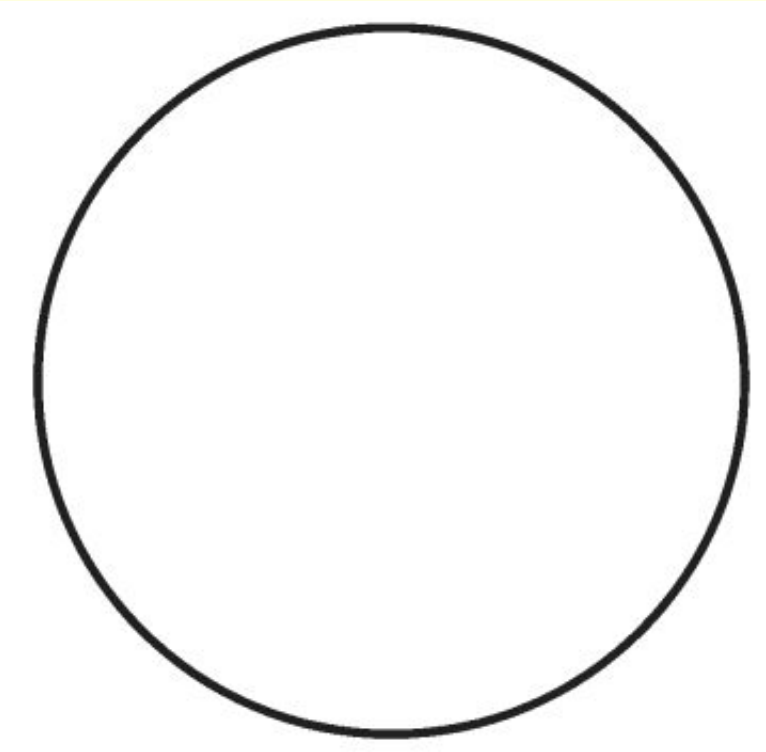
Effects of Aliasing in Graphics

Staircase

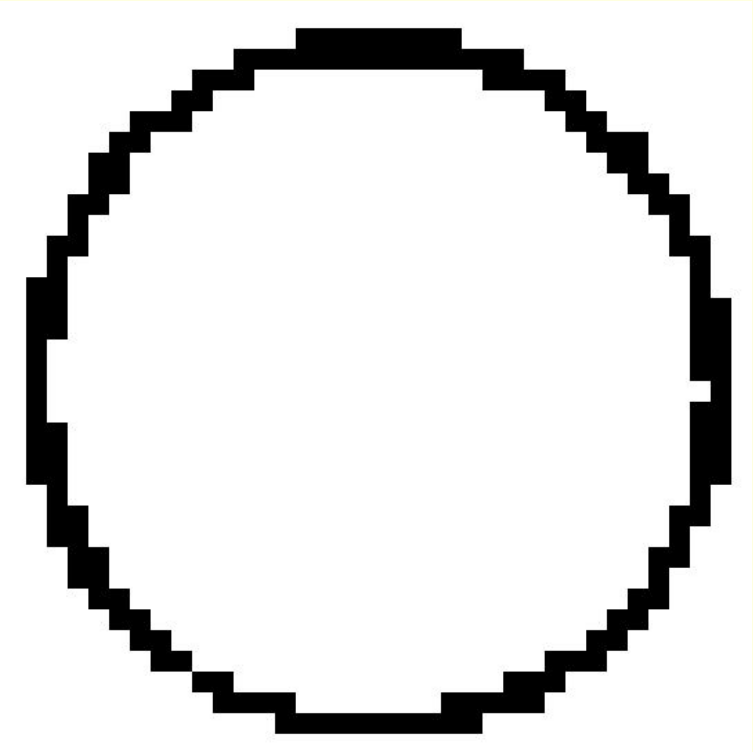
- A common example of aliasing effects is the staircase or jagged appearance
- We see it when scanconverting a primitive such as a line or a circle.
- We also see the stair steps or "jaggies" along the border of a filled region.

Effects of Aliasing in Graphics

- Jagged effect in rasterised graphics:



Vector representation of a circle

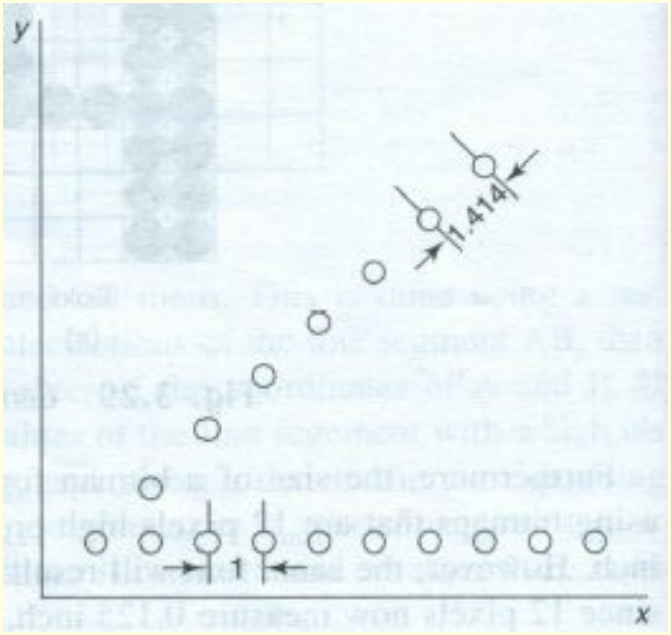


Jagged edges due to aliasing during the rasterisation process

Unequal Brightness

- Another artifact is the unequal brightness of lines of different orientation.
- A slanted line appears dimmer than a horizontal or vertical line, although all are presented at the same intensity level.
- The reason for this problem can be explained using Figure,
  - where the pixels on the horizontal line are placed one unit apart, whereas those on the diagonal line are approximately 1.414 units apart.
  - This difference in density produces the perceived difference in brightness

Unequal Brightness



Picket Fence Problem

The picket fence problem occurs when an object is not aligned with or does not fit into the pixel grid properly.

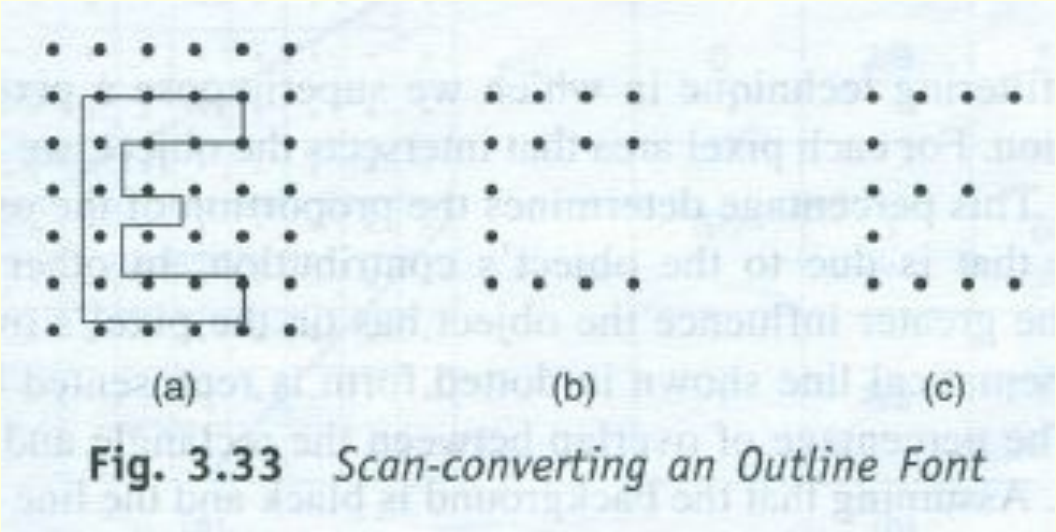


Fig. 3.33 *Scan-converting an Outline Font*

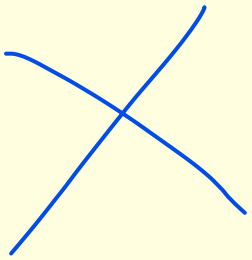
Anti-aliasing Techniques

- Increasing image resolution is a straightforward way to decrease the size of many aliasing artifacts
- We pay a heavy price in terms of system resource (going from W x H to 2W x 2H means quadrupling the number of pixels) and the results are not always satisfactory.
- On the other hand, there are techniques that can greatly reduce aliasing artifacts and improve the appearance of images without increasing their resolution.

  These techniques are collectively referred to as anti-aliasing techniques

Pre filteriung vs Post filtering

- Pre-filtering and post-filtering are two types of general-purpose anti-aliasing techniques.
- . In order to lessen the jagged appearance of lines and other contours in the image space, we seek to smooth out sudden intensity changes.
- A pre-flltering technique works on the true signal in the continuous space to derive proper values for individual pixels (filtering before sampling).
- Whereas a postfiltering technique takes discrete samples of the continuous signal and uses the samples to compute pixel values (sampling before filtering



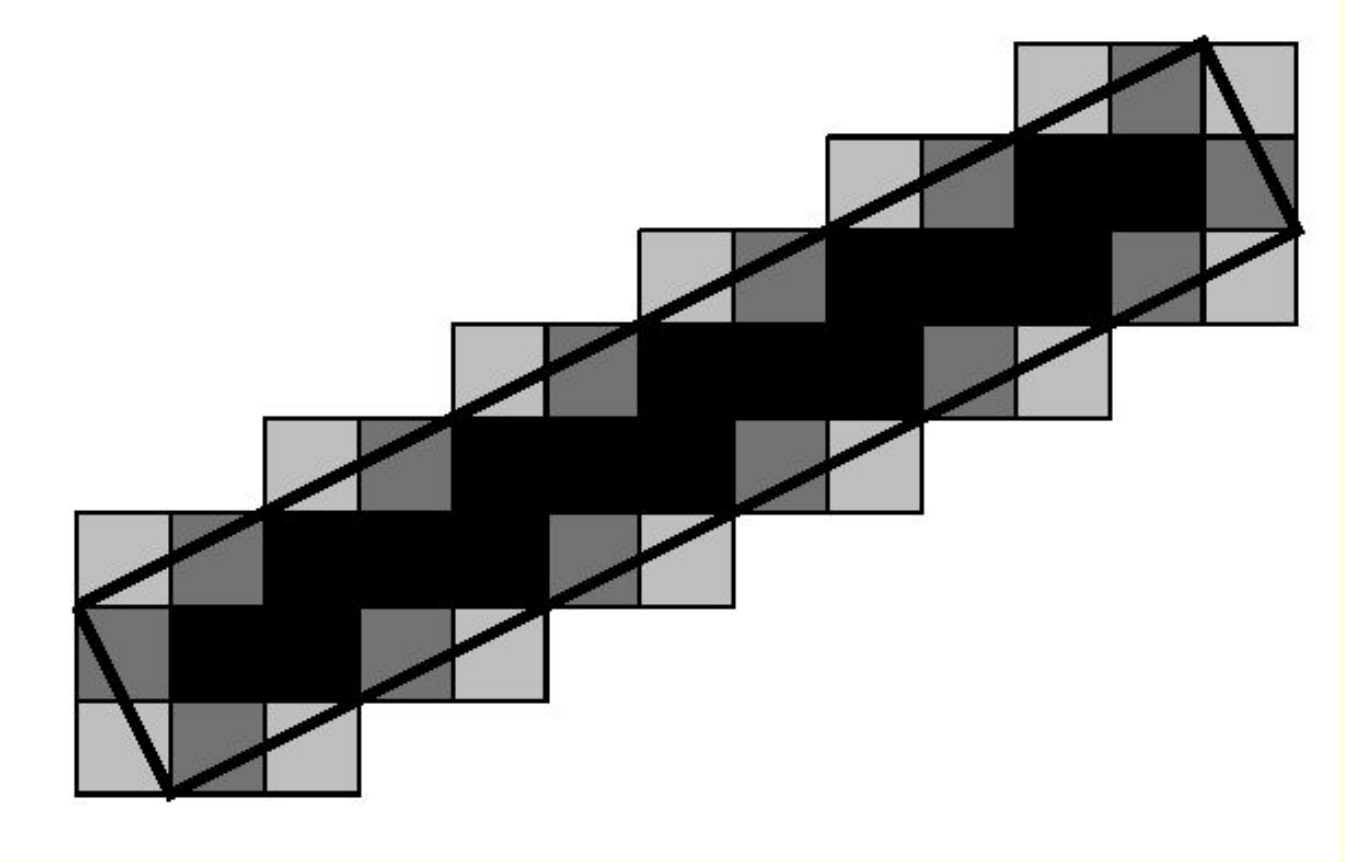
Area Sampling

- Area sampling is a pre-flltering technique in which we superimpose a pixel grid pattern onto the continuous object definition.
- For each pixel area that intersects the object, we calculate the percentage of overlap by the object.
- This percentage determines the proportion of the overall intensity value of the corresponding pixel that is due to the object's contribution.
- In other words, the higher the percentage of overlap, the greater influence the object has on the pixel's overall intensity value.

Un-weighted filtering

- **Unweighted area sampling interprets a line as** a long, but very thin rectangle.
- A pixel is not understood as a point, but as a small square that can be filled with colour.
- The intensity of the pixel is chosen proportionally to the area of the pixel's square that is covered by the rectangle that represents the line

Un-weighted filtering

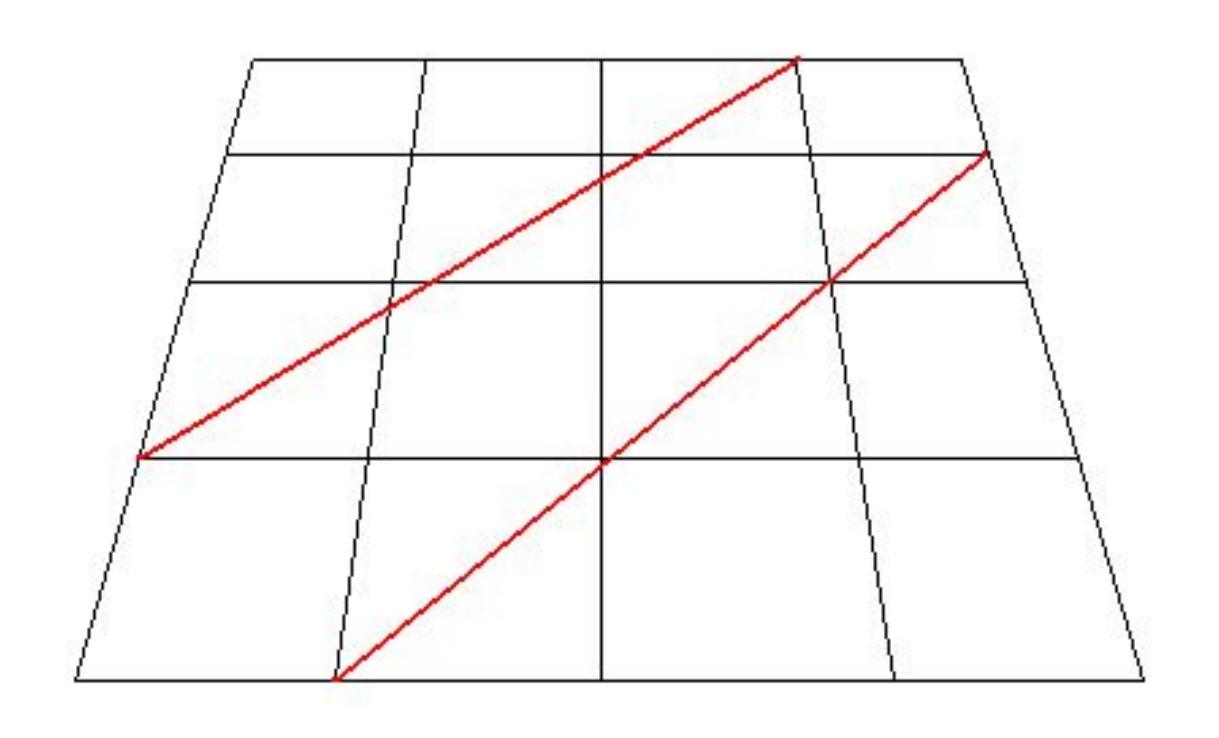


Anti-Aliasing Techniques

- In the method seen on the previous slides, the amount of coverage given to each pixel is determined irrespective of the distance from the center of the line.
- It is therefore known as *Un-weighted* filtering.
- The filter used to calculate the % coverage of each pixel in this method can be thought of as a cube covering an area of 1x1 pixels, as explained in the following slides…

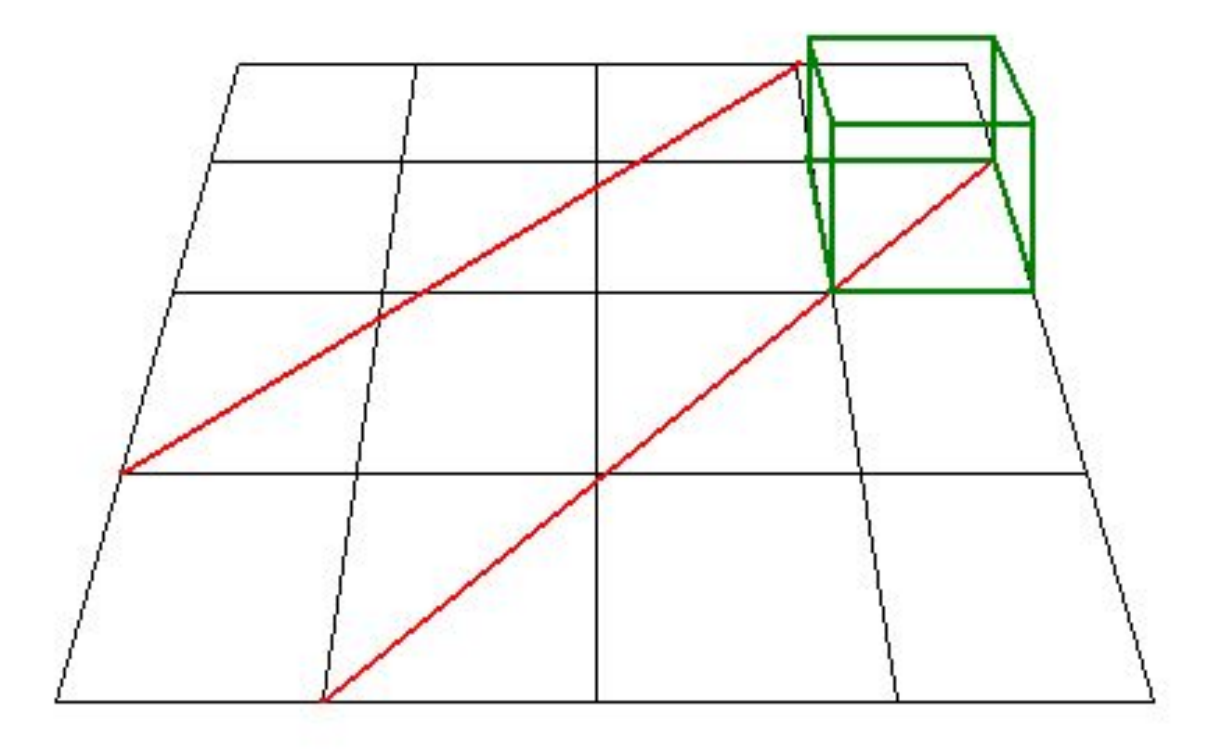
Unweighted Filtering

- Consider the line on a plane surface in a 3D space…



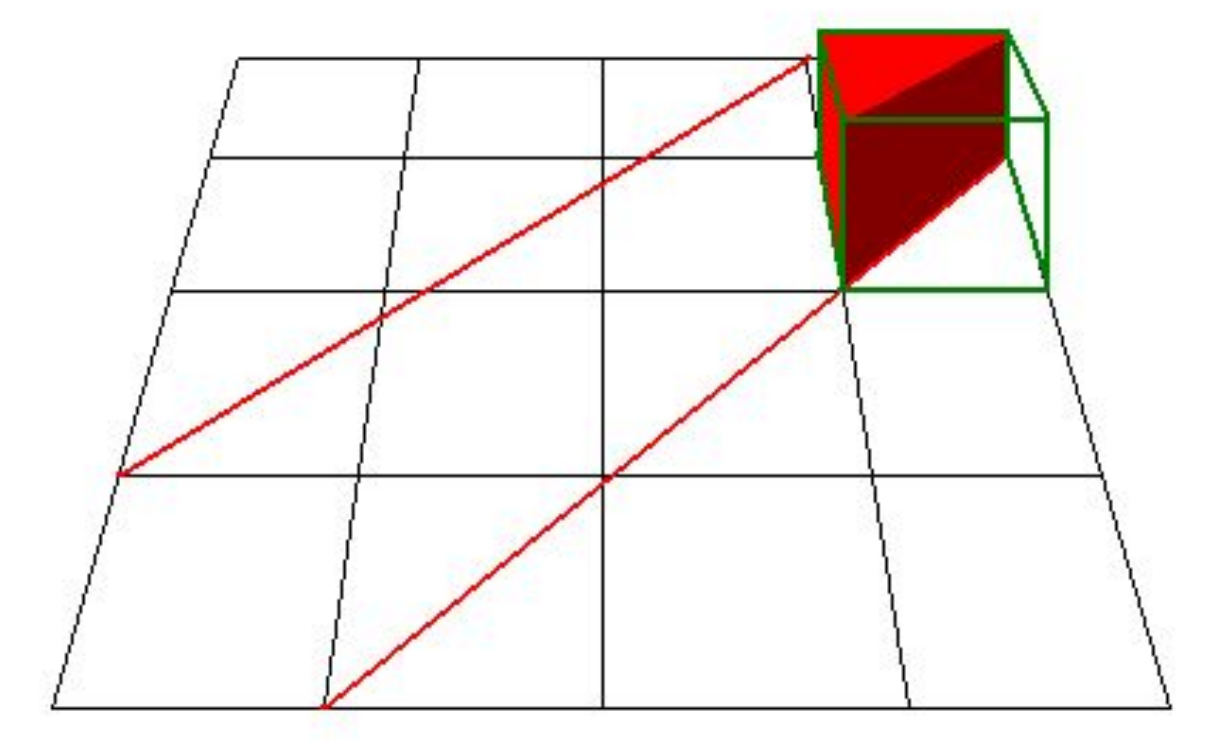
Unweighted Filtering

- A cube is extrapolated up from the plane for each pixel that the line intersects…



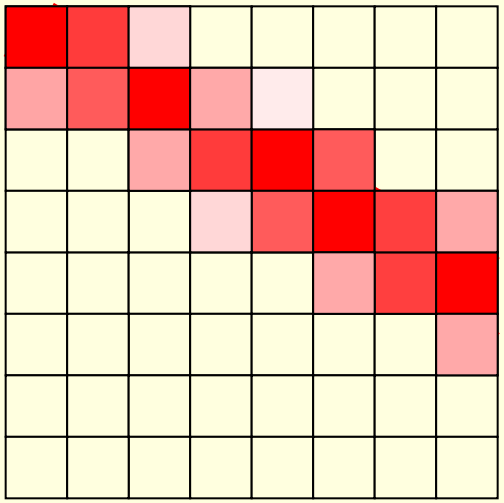
Unweighted Filtering

- The line is then extrapolated to fill a portion of this cube…



Unweighted Filtering

- The percentage of the cube filled by the line can now be calculated and used to shade this pixel.



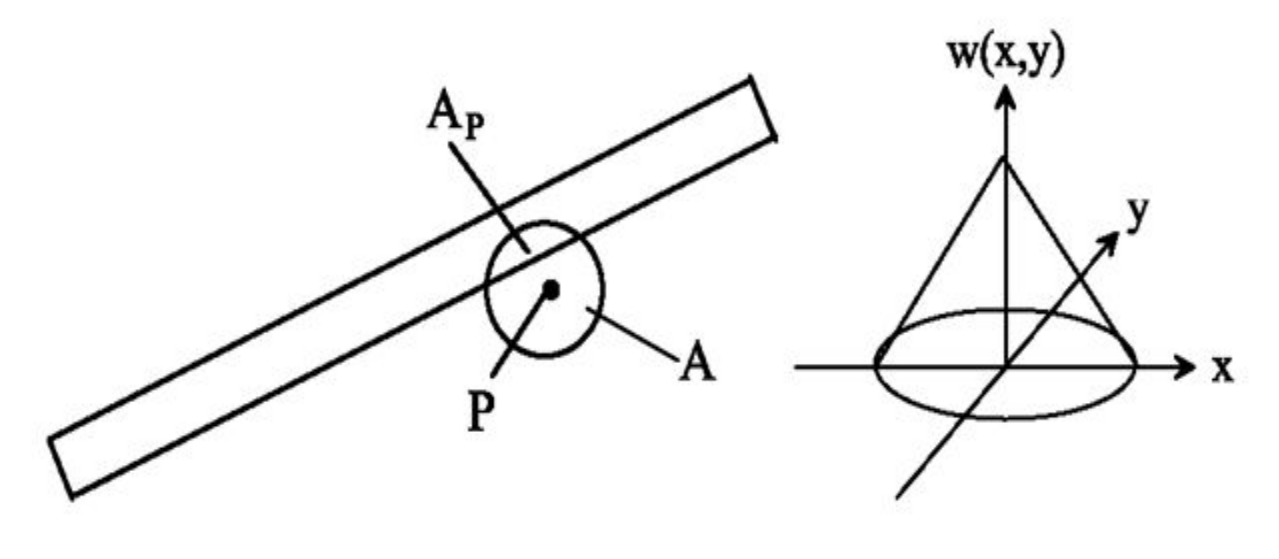
- *Unweighted* filtering is computationally simple, but better results can be achieved by using a *weighted* filter.

Weighted Filtering

- **Weighted area sampling does not only consider** the area of the pixel's square that is covered by the line rectangle, but takes also a weighting function w(x, y) into account.
- w(x,y) has the highest value in the centre of the pixel and decreases with increasing distance.
- A typical weighting function is shown in Fig. 3.22. The weighting function is defined on a circle A around pixel P as can be seen in the left part of the figure.

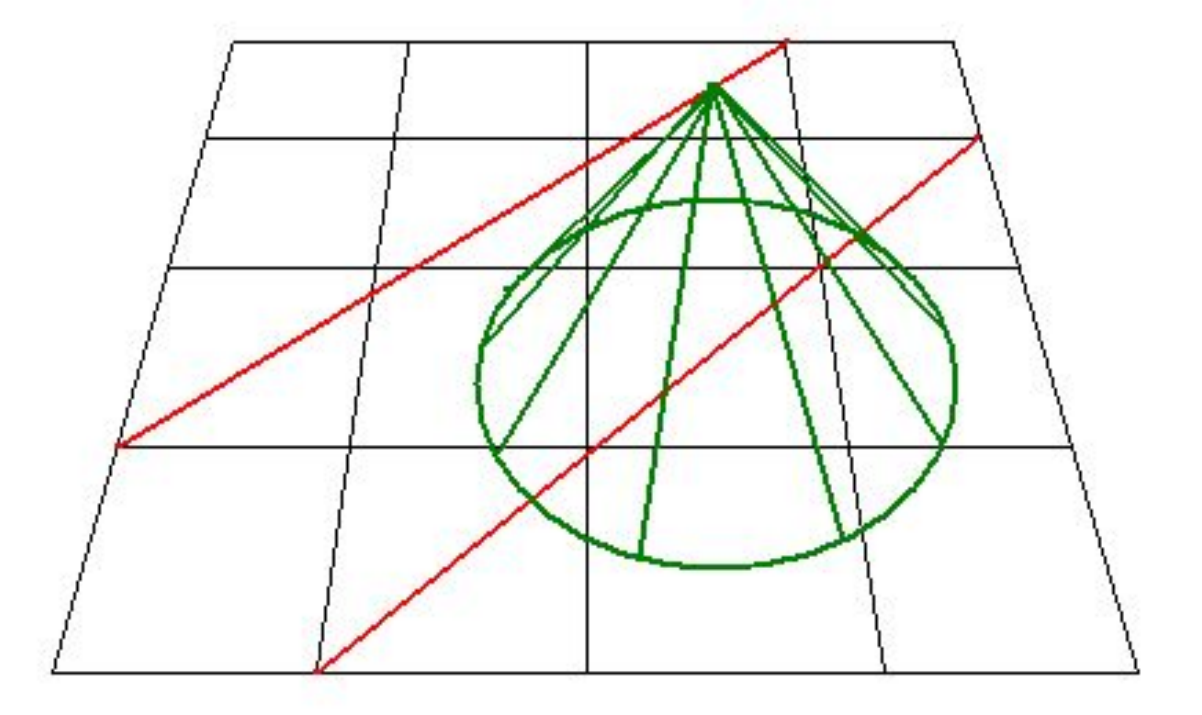
Weighted Filtering

- Intensity of the pixel is dependent on the line area occupied and the distance from the pixel's center



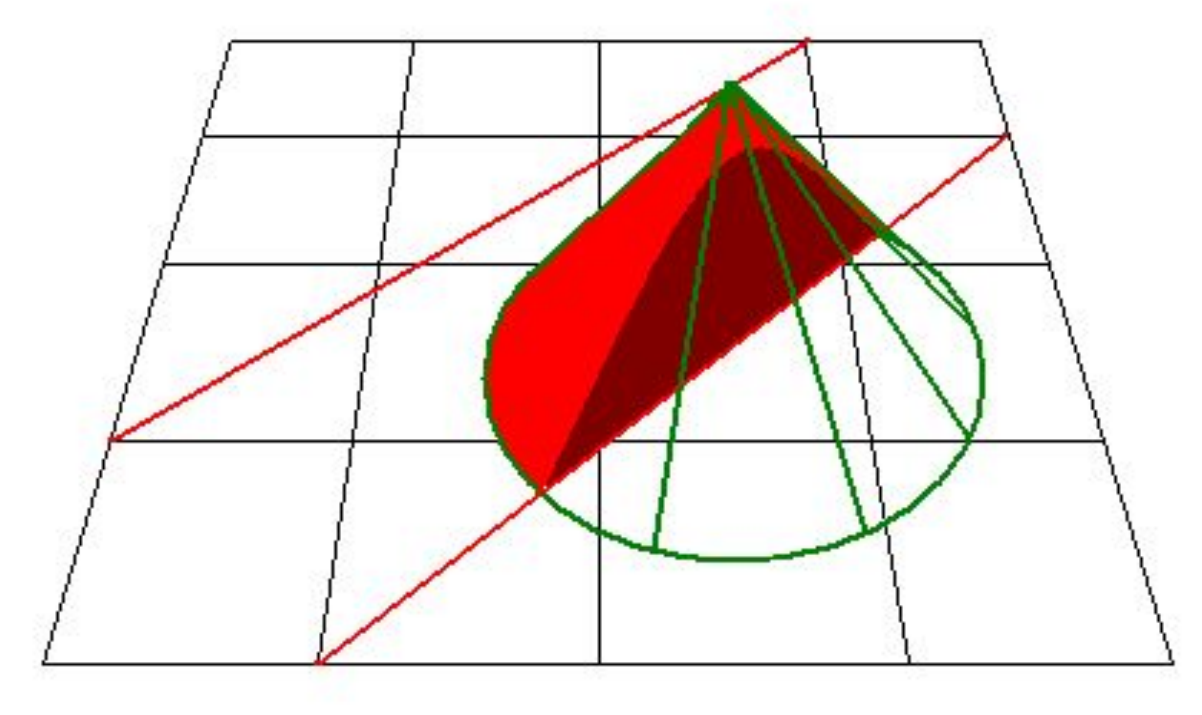
Weighted Filtering

- In weighted filtering, a cone is used in place of the cube.



Weighted Filtering

- The line is extrapolated into the cone and the percentage of the cone filled is calculated.



Weighted Filtering

- This *weighted filtering* gives a more accurate result by taking into account the pixels around the one currently being investigated.

- The use of a cone means that priority is given to line coverage closest to the center of the pixel in question.

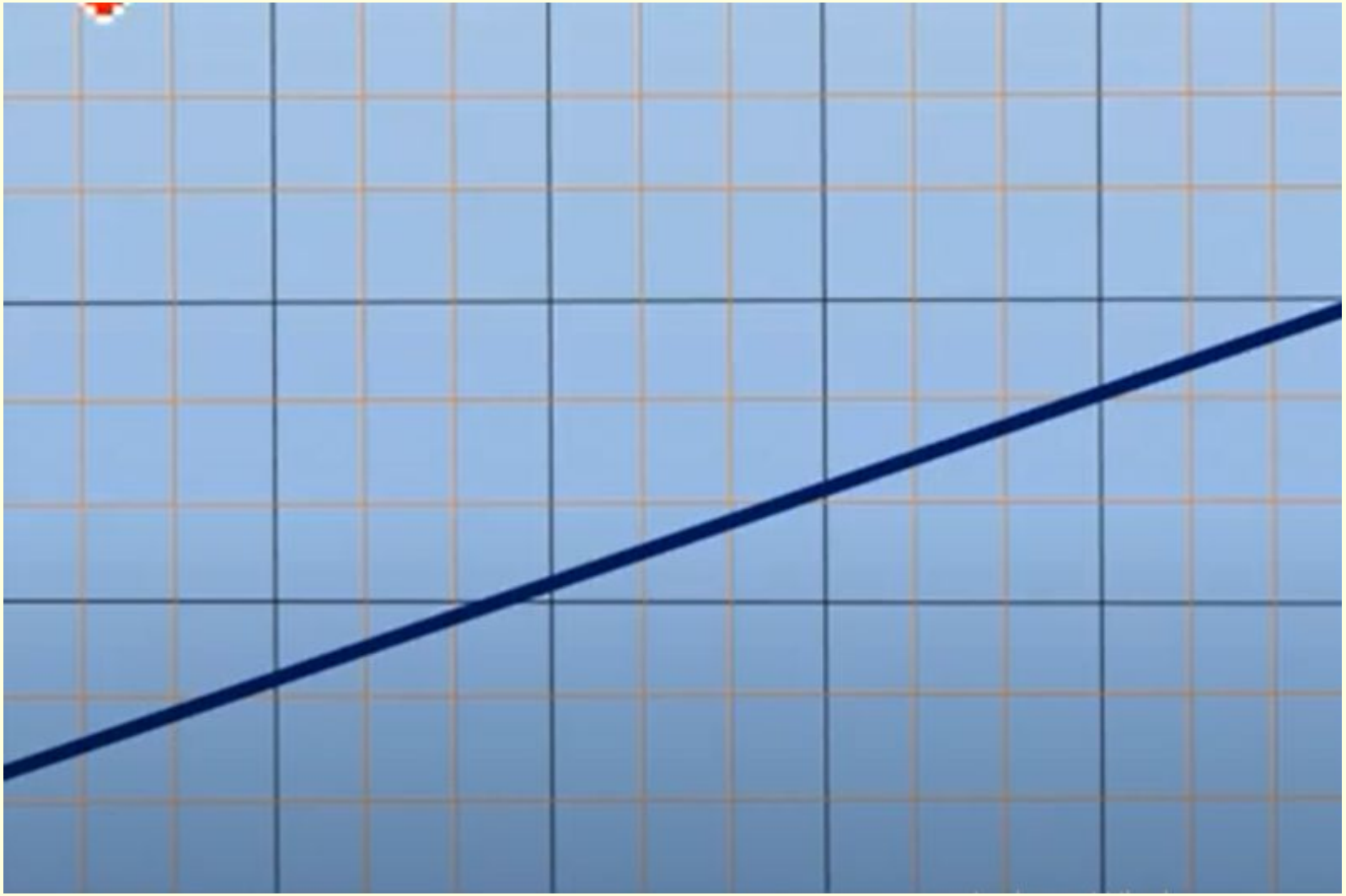
Supersampling

- Super sampling is often regarded as a post-filtering technique since discrete samples are first taken and then used to calculate pixel values.
- In this approach we subdivide each pixel into subpixels and check the position of each subpixel in relation to the object to be scan-converted.
- The object's contribution to a pixel's overall intensity value is proportional to the number of subpixels that are inside the area occupied by the object.

Supersampling

- Pixels divided into 9 sub pixels
- Line with width=0 considered for super sampling
- Count number of sub pixels overlapped by line
- Based on value of number of sub pixels overlapped by line assign intensity

Supersampling



Supersampling

- Supersampling is expensive computationally, but many high-end video cards provide on-board functionality to speed the process up.

- Modern video games strive for smooth, realistic edges and make extensive use of anti-aliasing techniques.

- Many games provide the user with options to select the level of supersampling used (2x, 4x, 8x) to balance the desired graphics level with the computing power available.