Image Interpretation

- Digitising images involves sampling and quantisation.
- A greyscale image can be considered to be a matrix of values.
- An image can also be considered to be a 2D function.

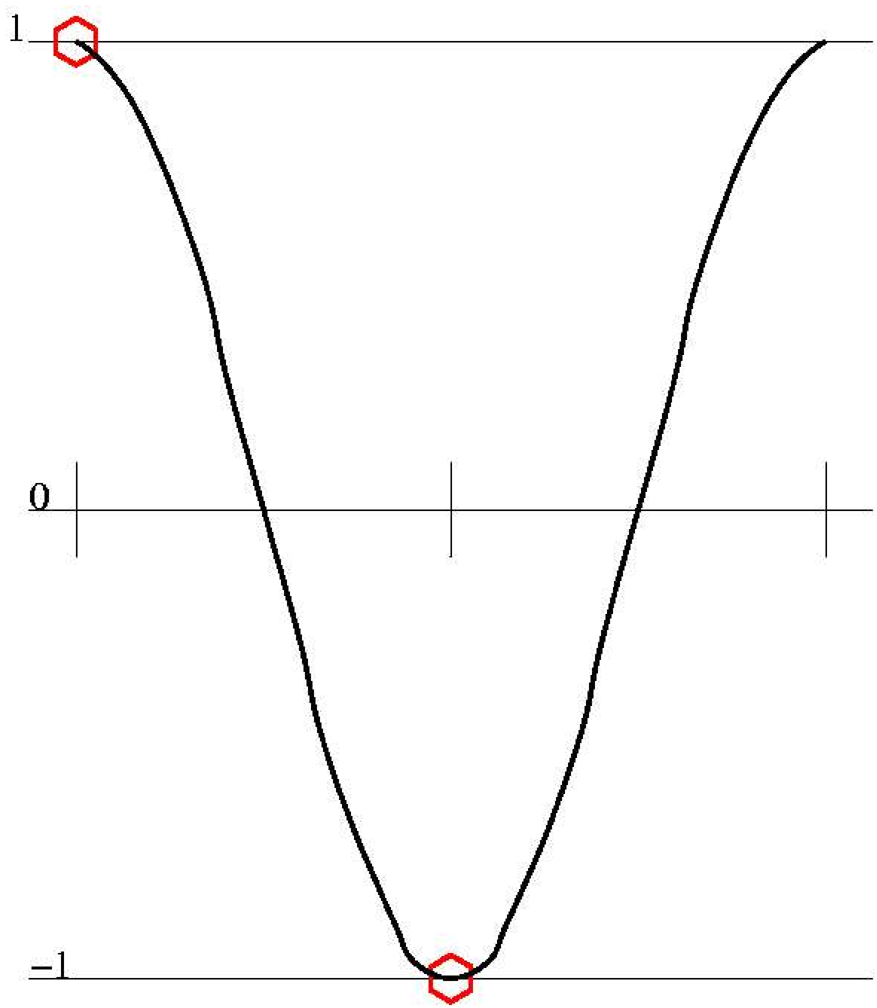
255	255	255	0	0	0
255	0	255	0	0	0
255	255	255	255	255	0
0	255	0	0	255	0
0	255	0	0	255	0
0	255	255	255	255	0
0	0	0	255	0	0
0	0	0	255	0	0
0	0	0	255	0	0
0	0	0	255	0	0

Fourier's theorem

Any continuous function can be expressed as a superposition of sinusoidal components of frequencies.

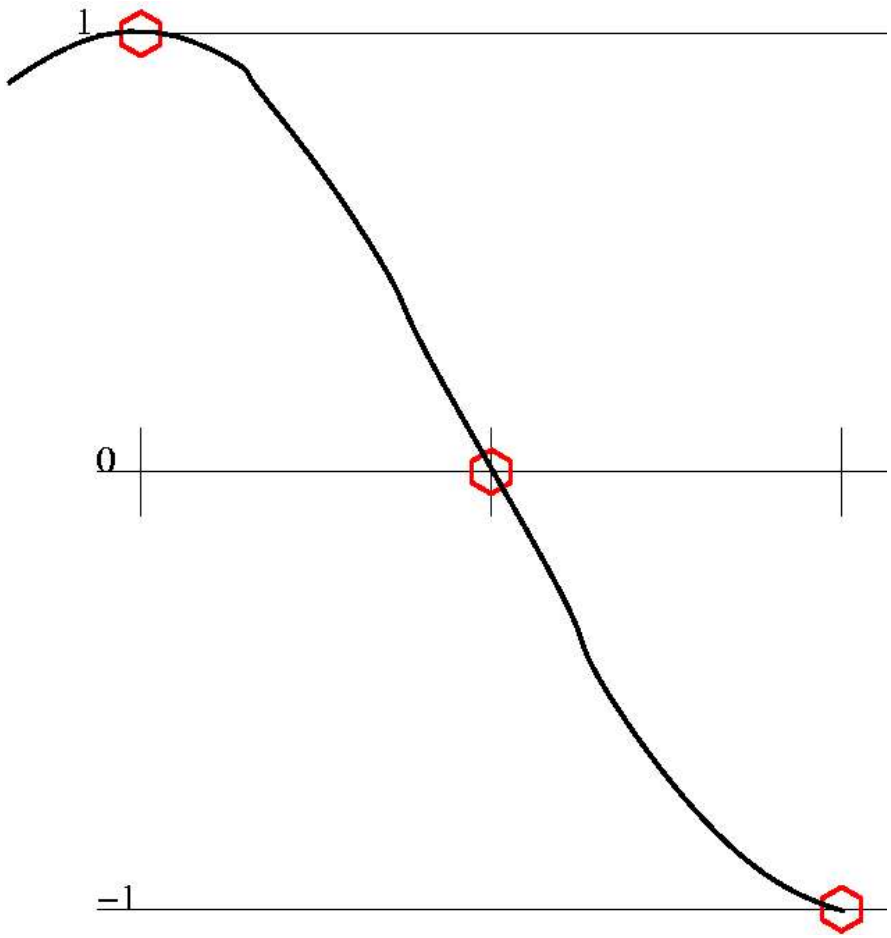
That is, all functions can be made up from a sum of *sin* or *cos*!

Minimum sampling of cosine



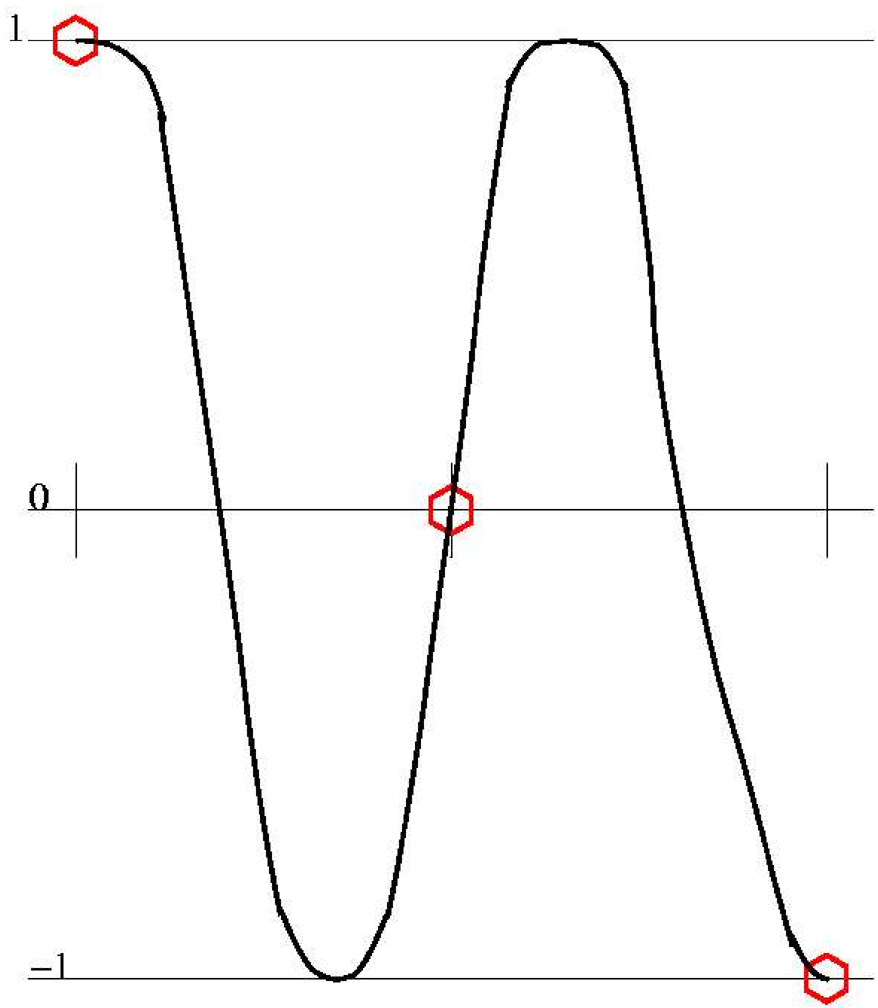
- Cosine is periodic so we need only consider one cycle.
- One point doesn't work
- Two points fixes it!

Half frequency



- Half the frequency of the previous function also samples fine at the previous sampling rate.

3/2 Nyquist Frequency



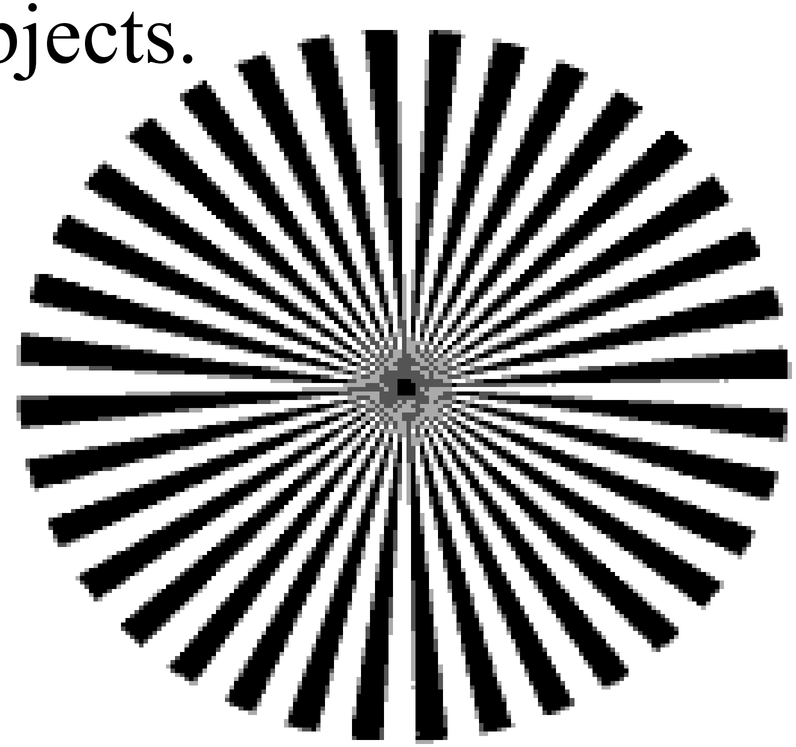
- Current sampling rate can't differentiate this function from the previous.
- The current sampling rate works for any lower frequency but not a higher frequency.
- This problem is known as aliasing.

Nyquist theorem

A continuous function can be reconstructed from discrete samples if and only if the samples were taken at a rate greater than twice the highest frequency of the continuous function.

What does frequency mean in an image?

- High frequency components of an image are the tiny sharp details.
- Low frequency components are the slowly varying large objects.



Aliasing in images

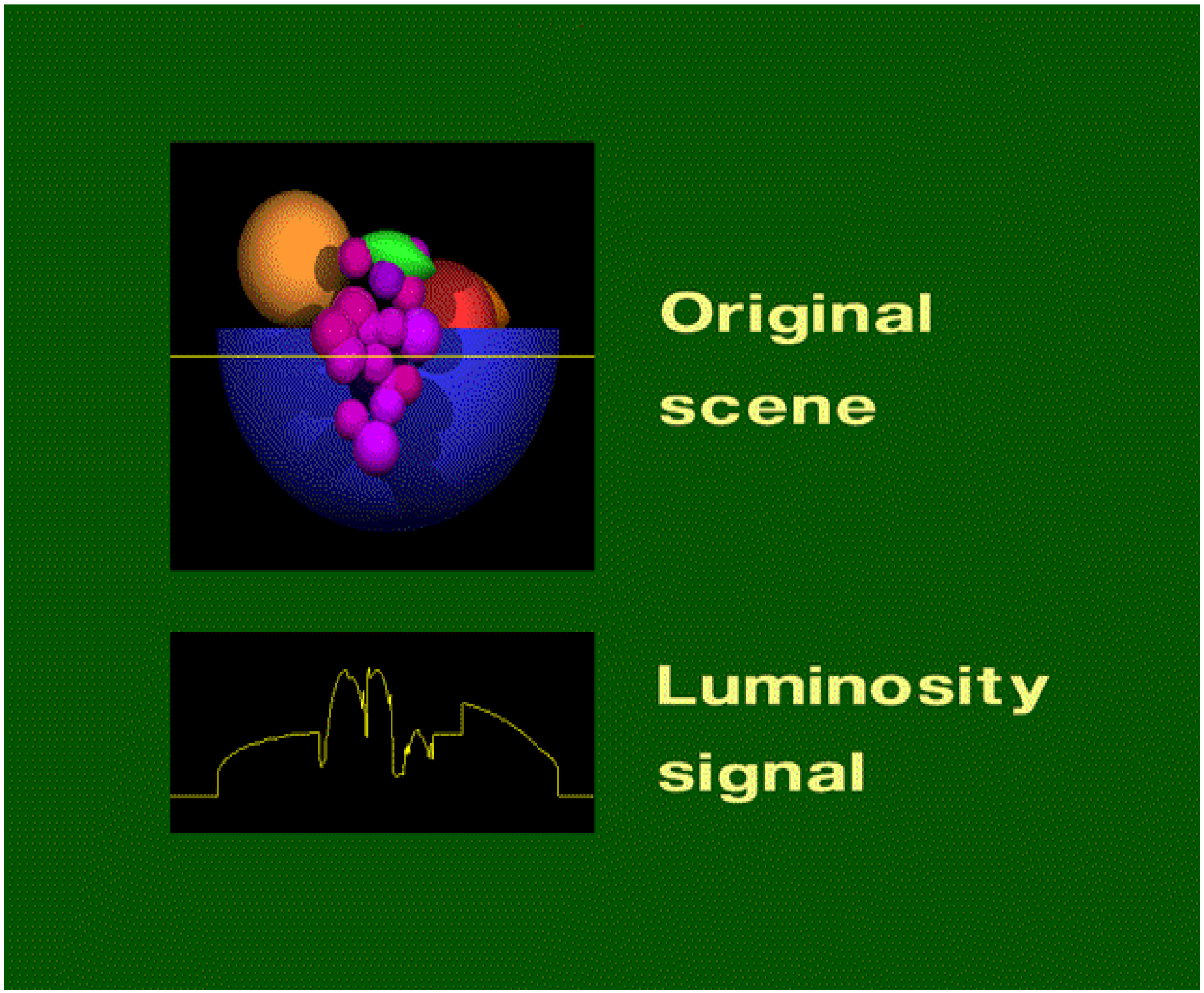
- Aliasing is the process of sampling a function which contains frequencies higher than the Nyquist frequency so that when the function is reconstructed bogus frequency components arise at frequencies lower than the Nyquist frequency.
- These bogus frequency components (usually low frequency) produce easy to see patterns. This is what Moire patterns are.

Acknowledgements

- The remaining slides in this lecture are a reproduction of work available at

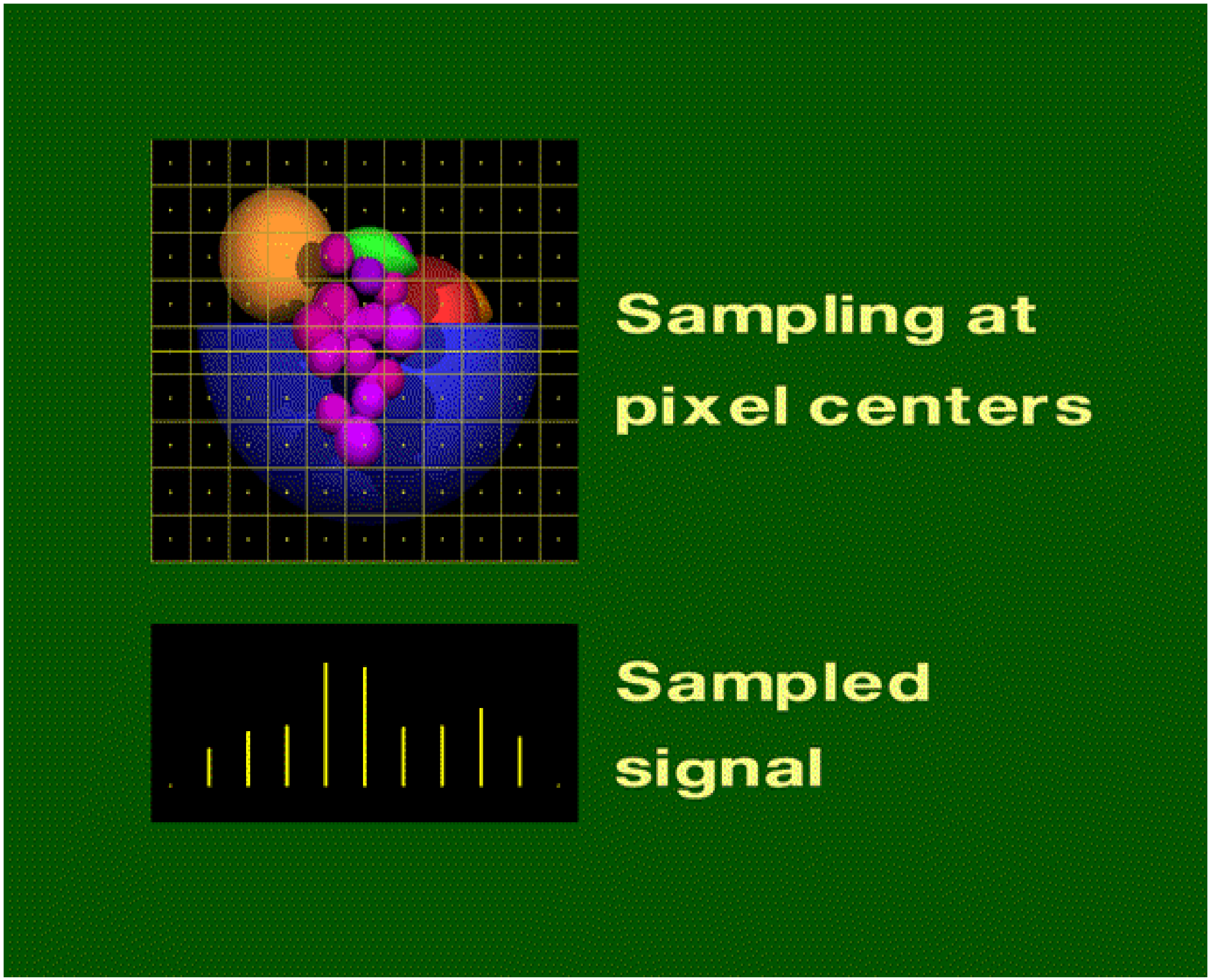
  http://www.siggraph.org/education/materials/HyperGraph/aliasing/alias0.htm

Original scene



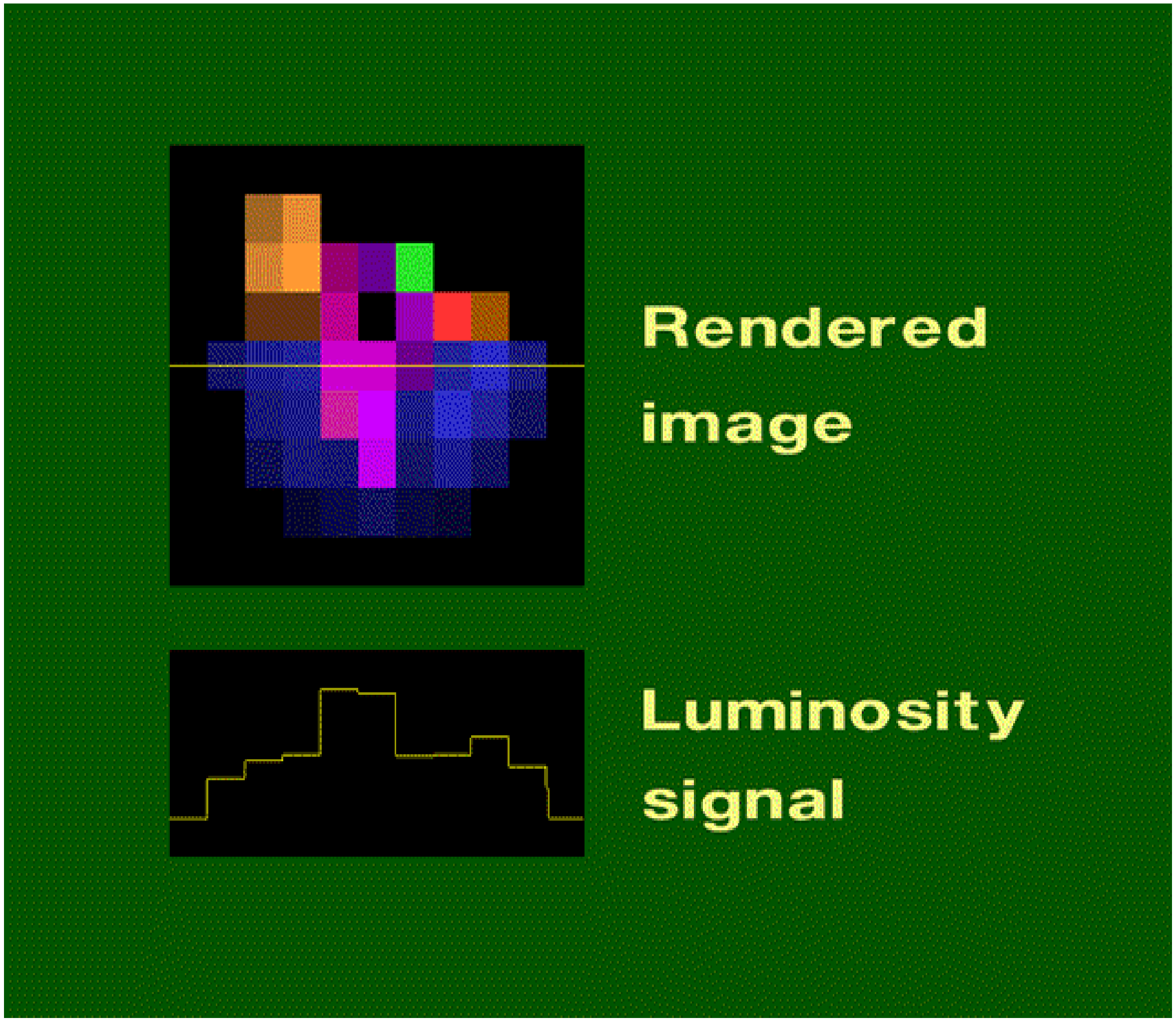
- One scanline in the fruitbowl is highlighted. The graph shows the luminosity (brightness) function of the highlighted scan line.

Sampled Scene



- The rectangular grid superimposed over the fruit bowl shows the size of the pixels.
- The dot in the middle of each square shows the position of a sample. The color at the sample point will be the color of the pixel in the rendered image.
- The graph shows the corresponding sampled luminosity function of the highlighted scanline. Notice that a lot of information has been lost.

Rendered Scene

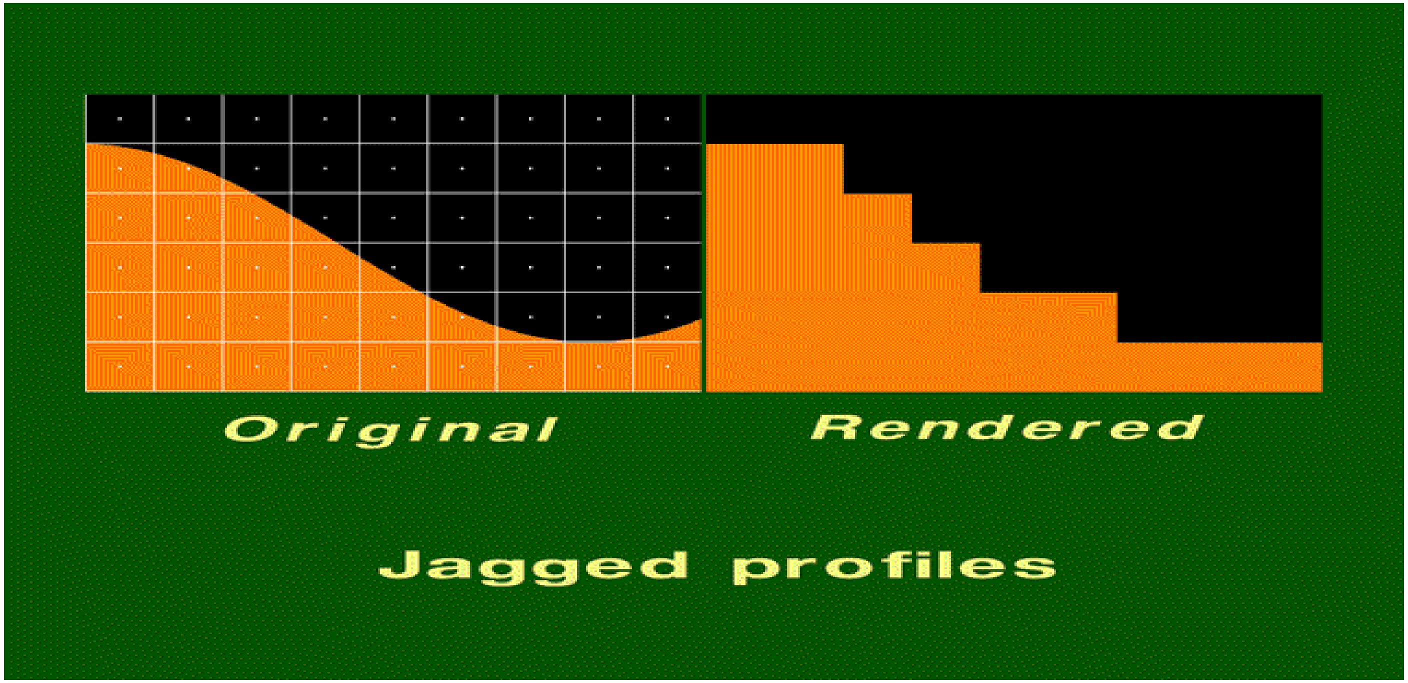


- The rendered image differs greatly from the original scene, as does the luminosity signal.
- Notice that the green leaf has moved to the right in the rendered image.

Effects caused by aliasing

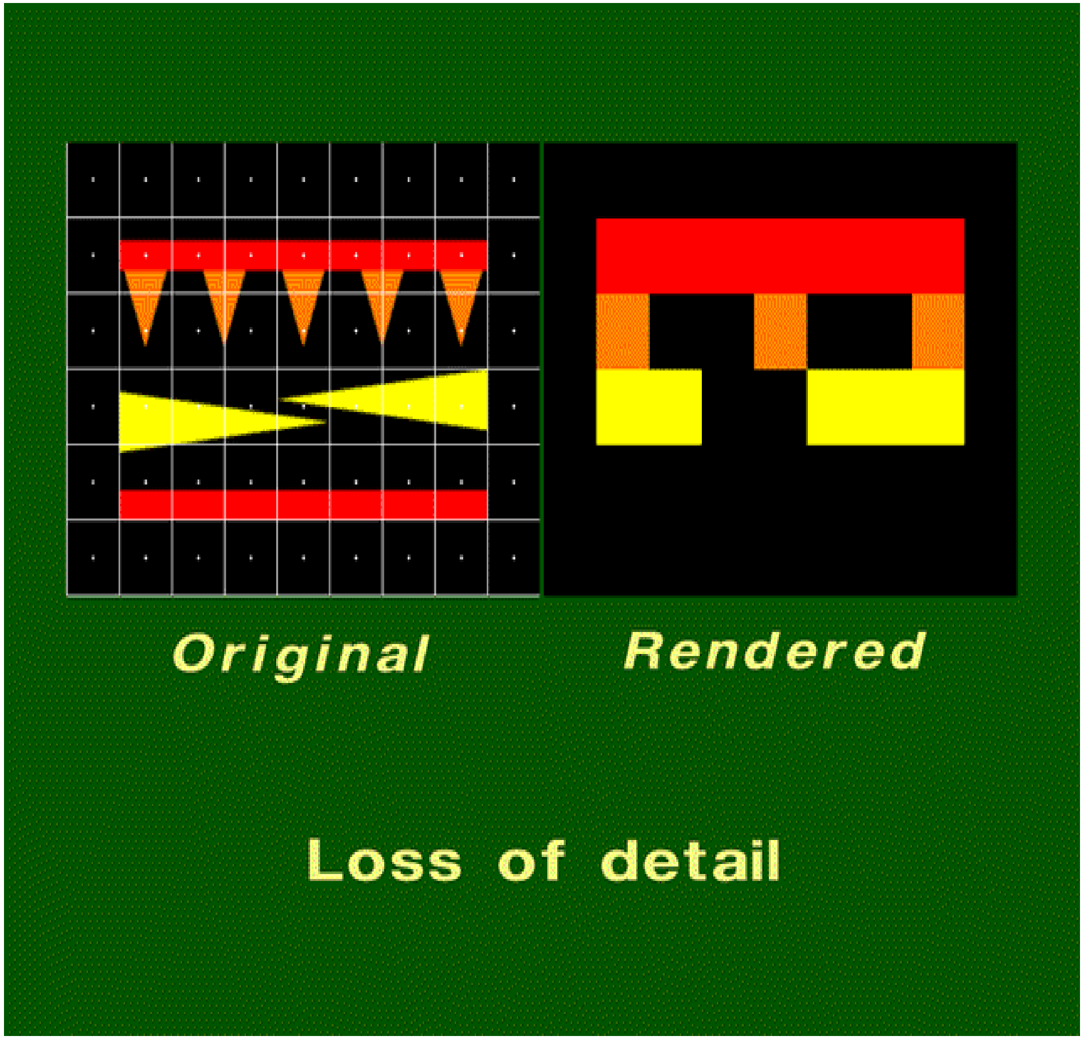
- The errors caused by aliasing are called artefacts.
- Common aliasing artefacts include
  - jagged profiles
  - disappearing or improperly rendered fine detail
  - disintegrating textures.

Jagged profiles



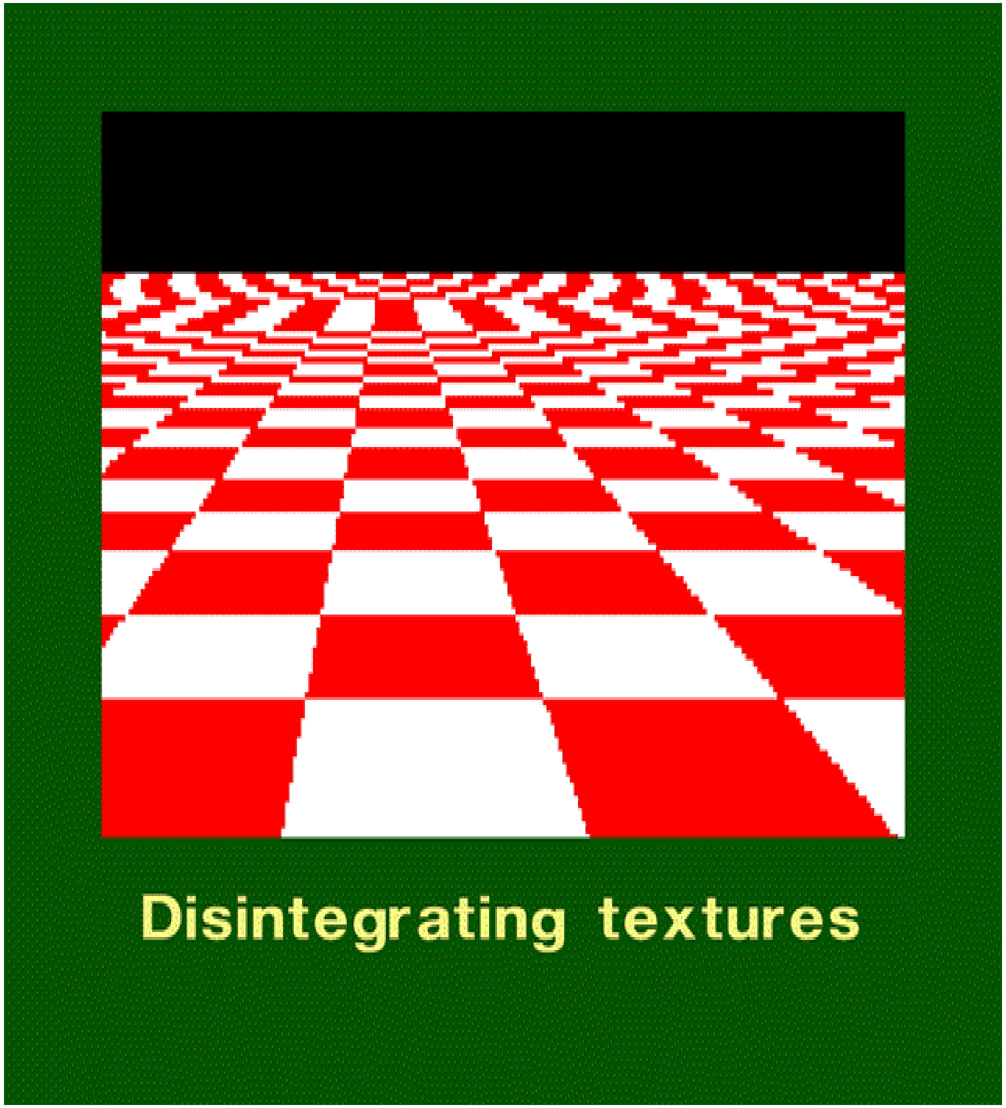
- The picture on the left shows the sampling grid superimposed on the original scene.
- The picture on the right is the rendered image.
- A jagged profile is quite evident in the rendered image.
- Also known as "jaggies", jagged silhouettes are probably the most familiar effect caused by aliasing.
- Jaggies are especially noticeable where there is a high contrast between the interior and the exterior of the silhouette.

Loss of Detail



- The original scene on the left shows a group of small polygons.
- In the rendered scene, one of the two red rectangles disappears entirely, and the other doubles in width. Two of the orange triangles disappear.
- Although the two yellow triangles are identical in size, one is larger than the other in the rendered image.

Disintegrating textures.

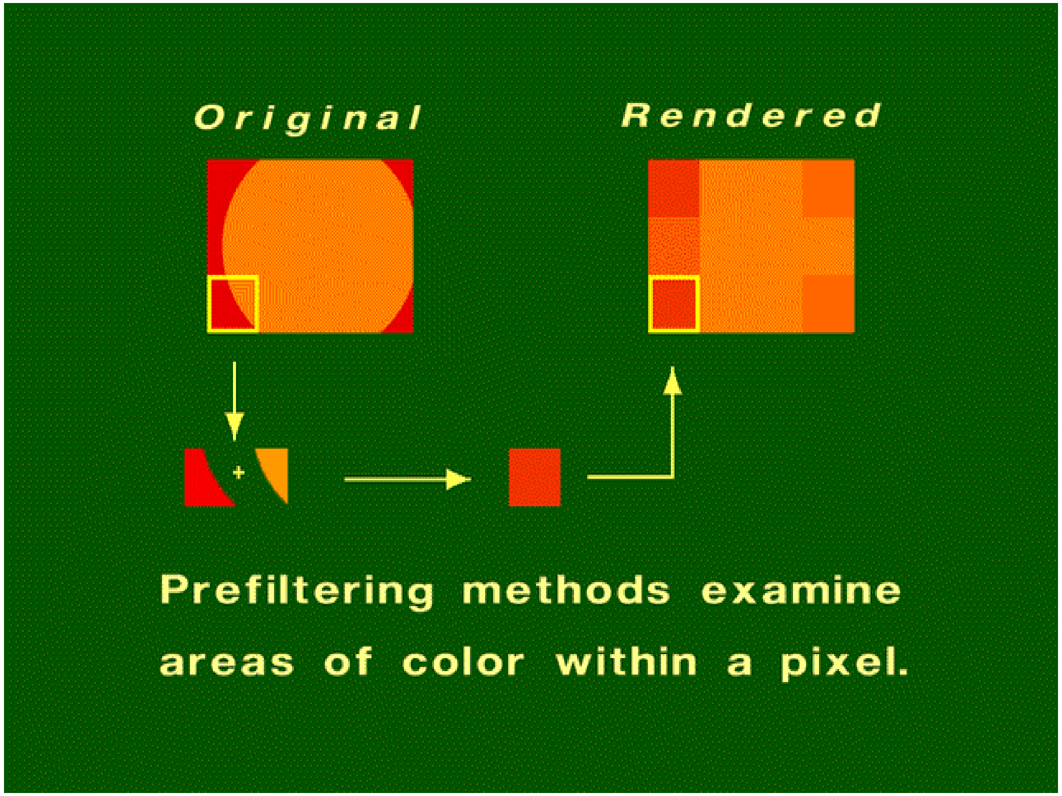


- This is a checkered texture on a plane.
- The checkers should become smaller as the distance from the viewer increases.
- However, the checkers become larger or irregularly shaped when their distance from the viewer becomes too great.
- Simply increasing the resolution will not remove this artefact. Increasing the resolution will only move the artefact closer to the horizon.

Antialiasing techniques

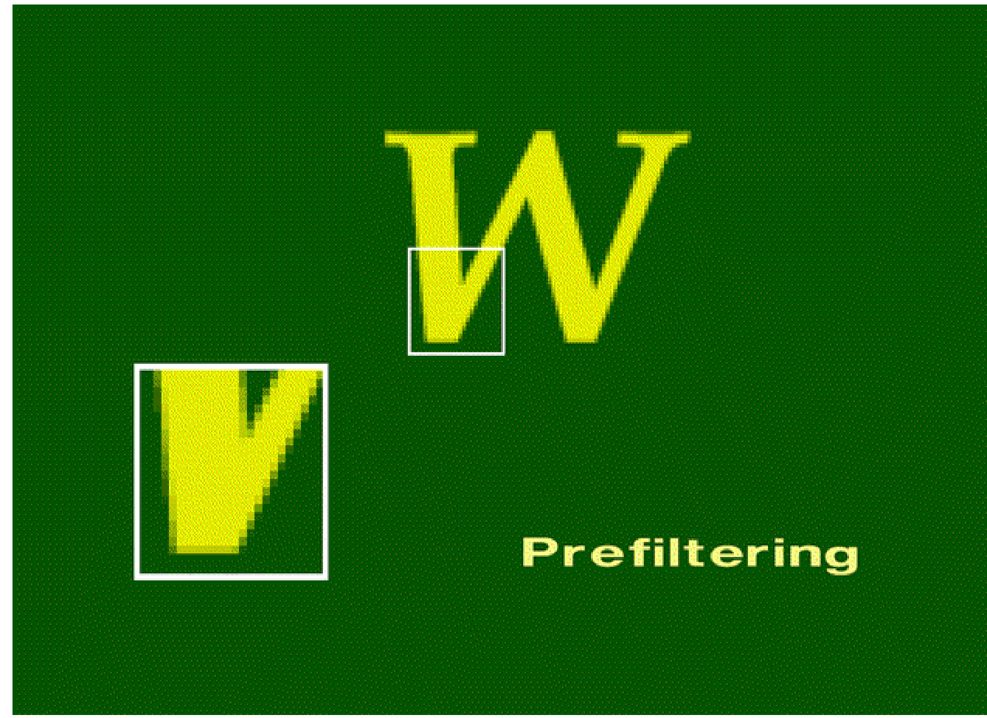
- Antialiasing methods were developed to combat the effects of aliasing. The two major categories of antialiasing techniques are prefiltering and postfiltering.
- Prefiltering methods treat a pixel as an area, and compute pixel color based on the overlap of the scene's objects with a pixel's area.
- Postfiltering, also known as supersampling, is the more popular approach to antialiasing. For each displayed pixel, a postfiltering method takes several samples from the scene and computes an average of the samples to determine the pixel's color.

Prefilter technique



- The original scene is a filled orange circle on a red background.
- All of the pixels inside the circle are 100 percent orange.
- All the pixels on the boundary of the circle have some area that is red and some area that is orange. Forty percent of the highlighted pixel is orange and 60 percent of its area is red.
- The computed color for the highlighted pixel is 40 percent orange and 60 percent red.

Prefilter Demo



Without antialiasing, the jaggies are harshly evident.

Along the character's border, the colors are a mixture of the foreground and background colors.

Postfilter technique

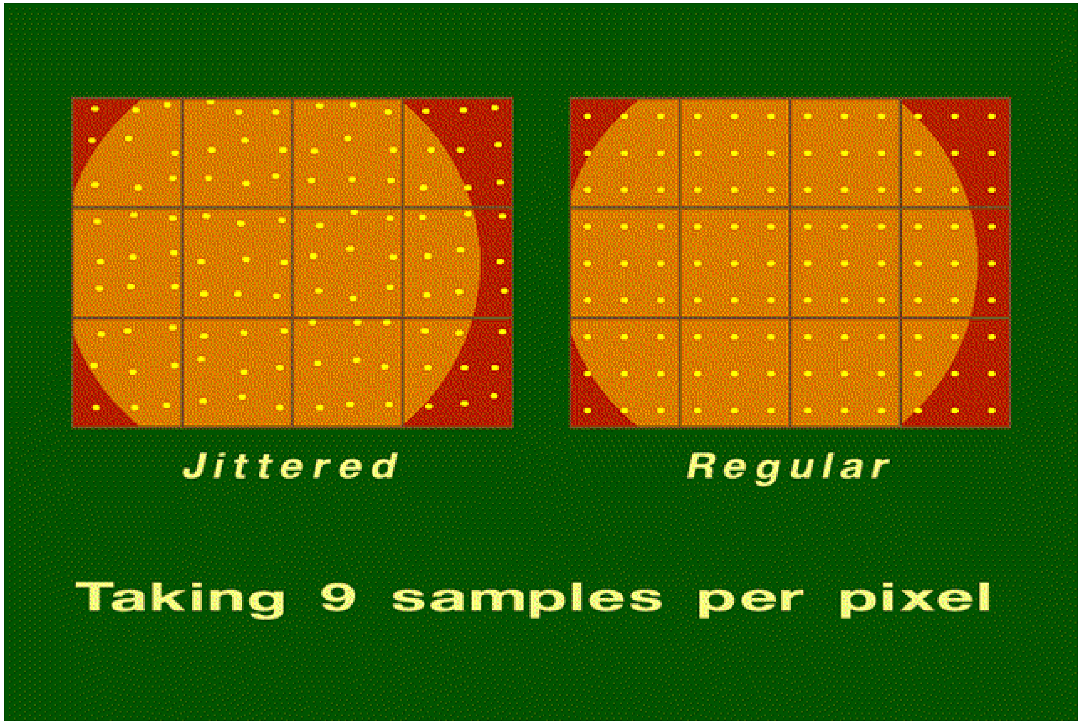
- The two steps in the postfiltering process are:

1) Sample the scene at n times the display resolution. For example, suppose the display resolution is 512x512. Sampling at three times the width and three times the height of the display resolution would yield 1536x1536 samples.

2) The color of each pixel in the rendered image will be an average of several samples. For example, if sampling were performed at three times the width and three times the height of the display resolution, then a pixel's color would be an average of nine samples. A filter provides the weights used to compute the average.

Postfilter Sampling

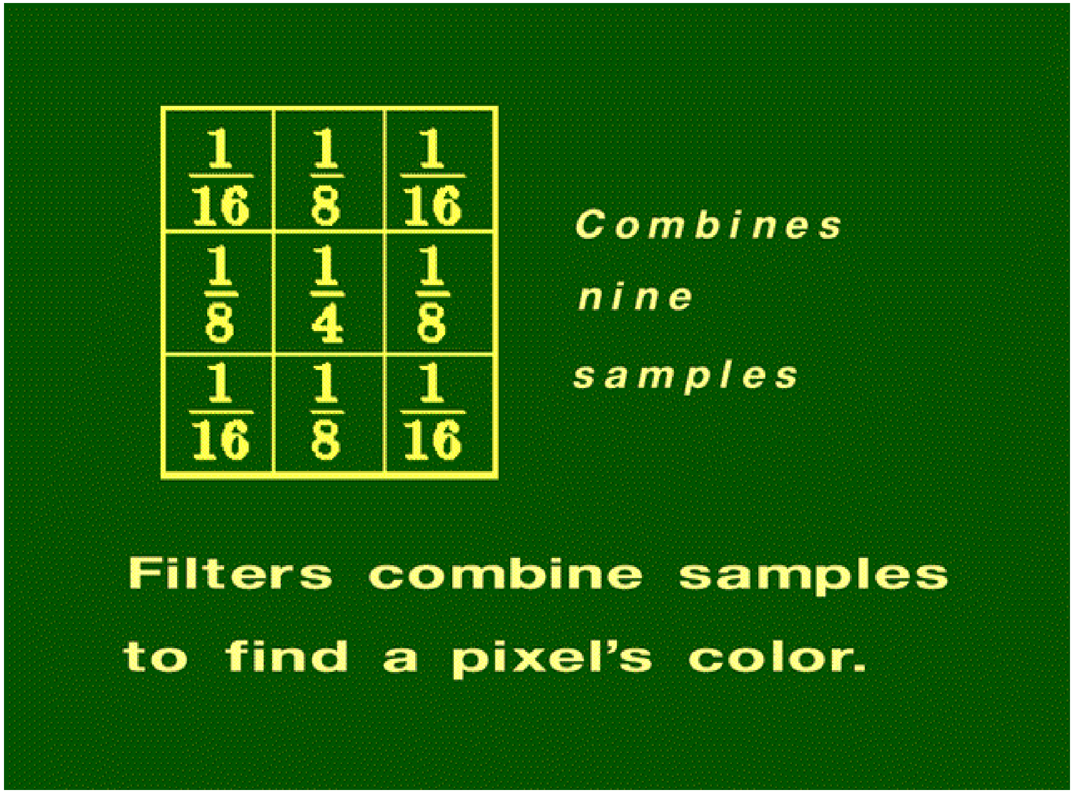
- In both figures, the display resolution is four pixels wide by three pixels high.
- The superimposed grid depicts the size of a pixel. Both figures show supersampling at three times the height and three times the width of the display resolution.
- In the right figure, the samples are regularly spaced. In the left figure, the positions of samples are displaced by a random amount. The random amount is small relative to the size of the pixel.



This method of perturbing the sample positions is known as "jittering." Jittering adds noise to the rendered image. The advantage of jittering is that the human eye tolerates noise more easily than it tolerates aliasing artefacts, and as a result, humans perceive a higher quality in the rendered image.

Postfilter filter

- Filters combine samples to compute a pixel's color.
- The weighted filter shown on the slide combines nine samples taken from inside a pixel's boundary. Each sample is multiplied by its corresponding weight and the products are summed to produce a weighted average, which is used as the pixel color.
- In an unweighted filter, each sample has equal influence in determining the pixel's color. In other words, an unweighted filter computes an unweighted average.



In this filter, the center sample has the most influence. The other type of filter is an unweighted filter.