

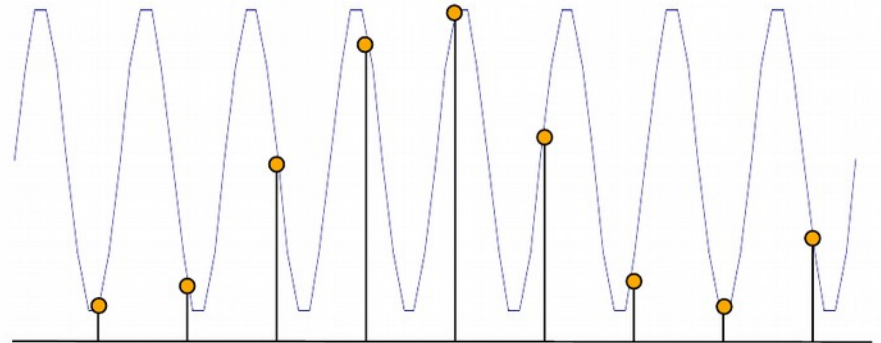
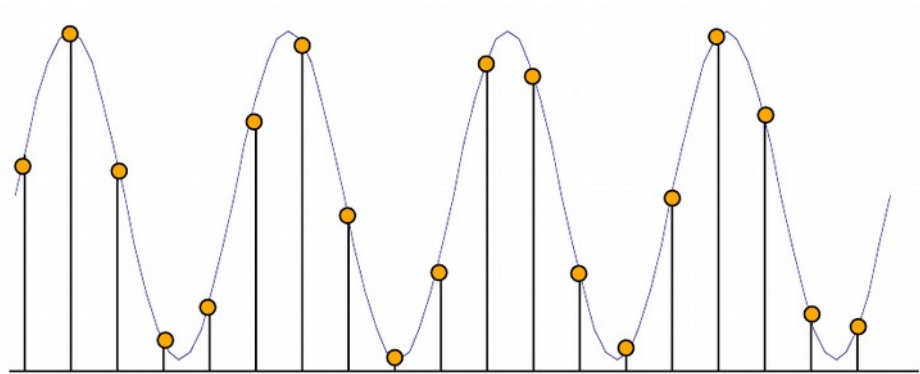
Computer Graphics:

8 - Aliasing and Antialiasing

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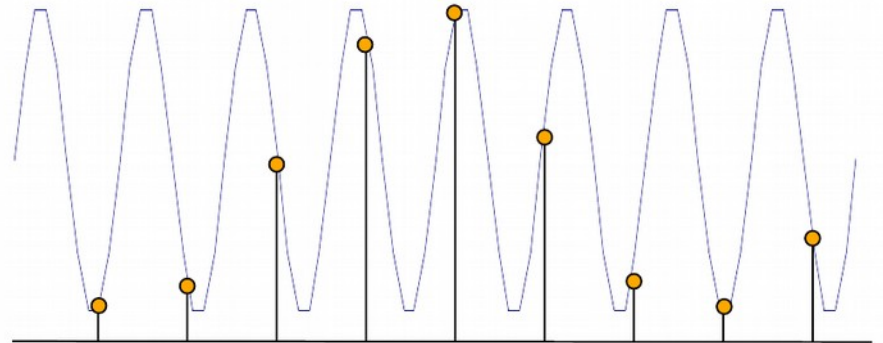
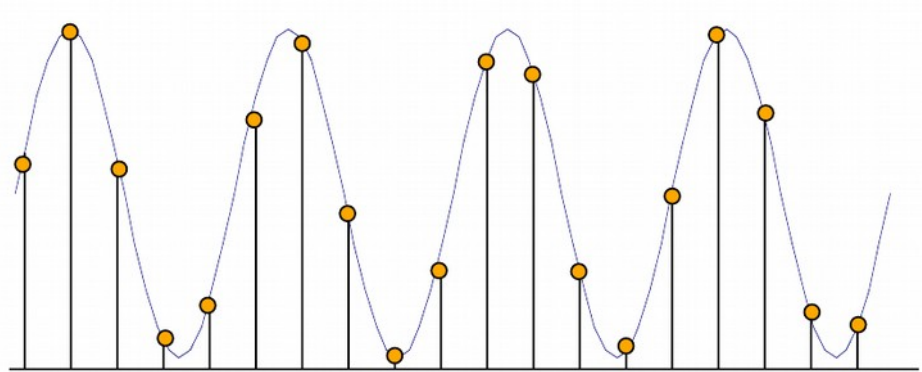
Introduction

- Suppose you have a signal you want to sample at regular intervals: sampled points are marked in orange
- In the top sinus wave, the sample is fast enough that the reconstructed signals will have the same frequency than the original signal
- In the second wave, instead, the reconstructed wave will be appearing to have a much lower frequency than the original
- This is called an aliased signal



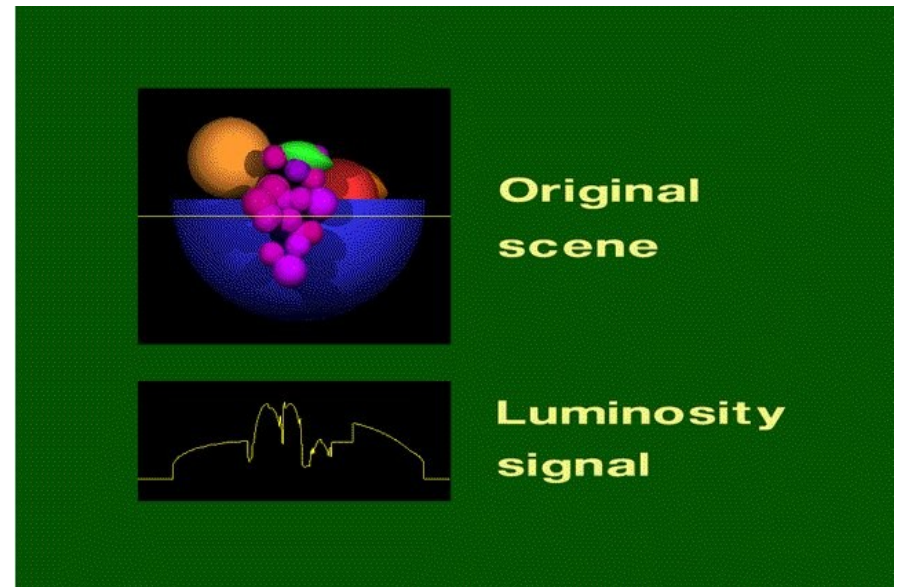
The Nyquist theorem

- In point sampling theory, there is the Nyquist theorem that states that to reconstruct accurately a signal, the sampling rate must be ≥ 2 times the highest frequency in a signal
- The consequence of this is the fact that music is sampled at 44kHz to reproduce the audible spectrum up to 22kHz
- Any frequencies over 22kHz are removed from the system so as not to have low frequencies due to aliasing

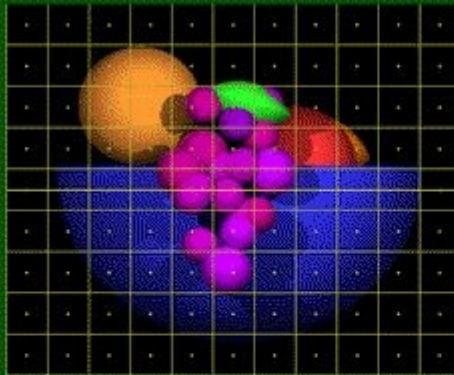


Images as functions

- What does this have to do with graphics?
- An Image can always be seen as a luminosity function $F(x,y)$ of values defined at the pixel centres
- As such it can be seen as the point sampling of a continuous function
- A row of pixels can be therefore seen as a function of the variable x
- Writing pixel values is exactly like sampling the function at the pixel centres



Sampling images

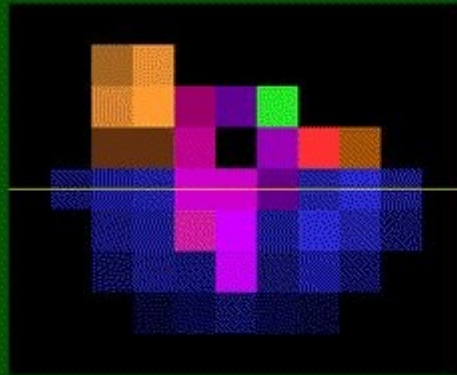


**Sampling at
pixel centers**



**Sampled
signal**

Rendering images



**Rendered
image**



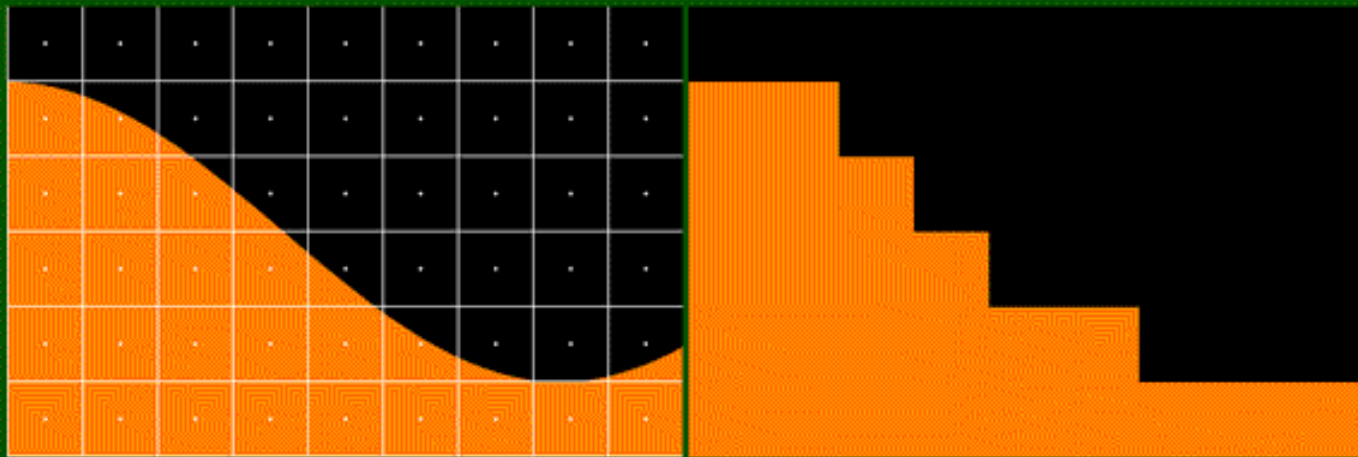
**Luminosity
signal**

Sampling theory and graphics

- When the pixel distance is higher than the Nyquist limit of the sampled signal frequencies, one becomes jaggies
- Jaggies are high frequencies appearing as low frequencies which produce regular patterns easy to see



Effects of aliasing

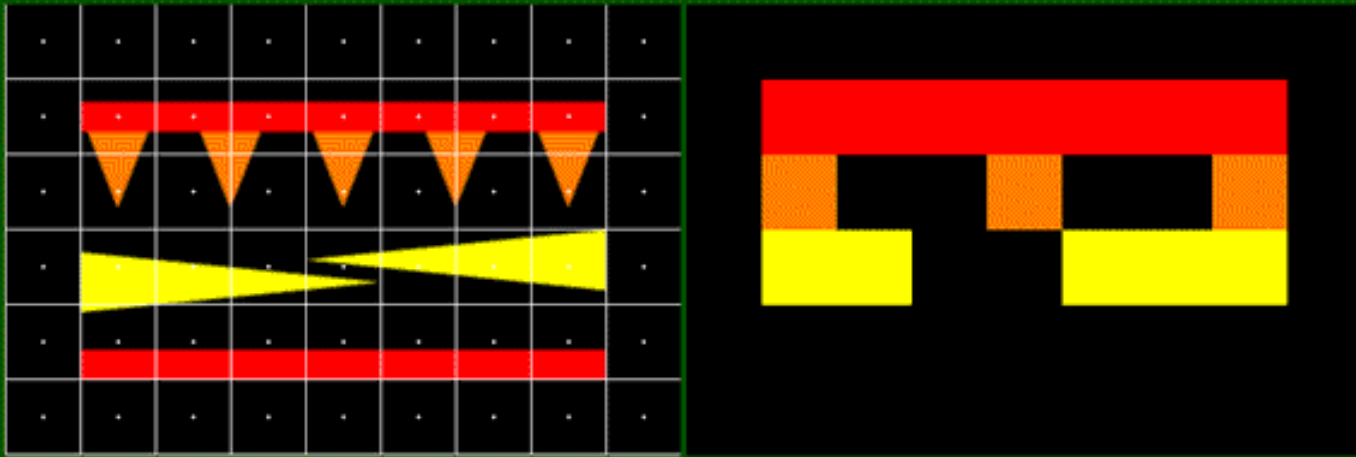


Original

Rendered

Jagged profiles

Effects of aliasing

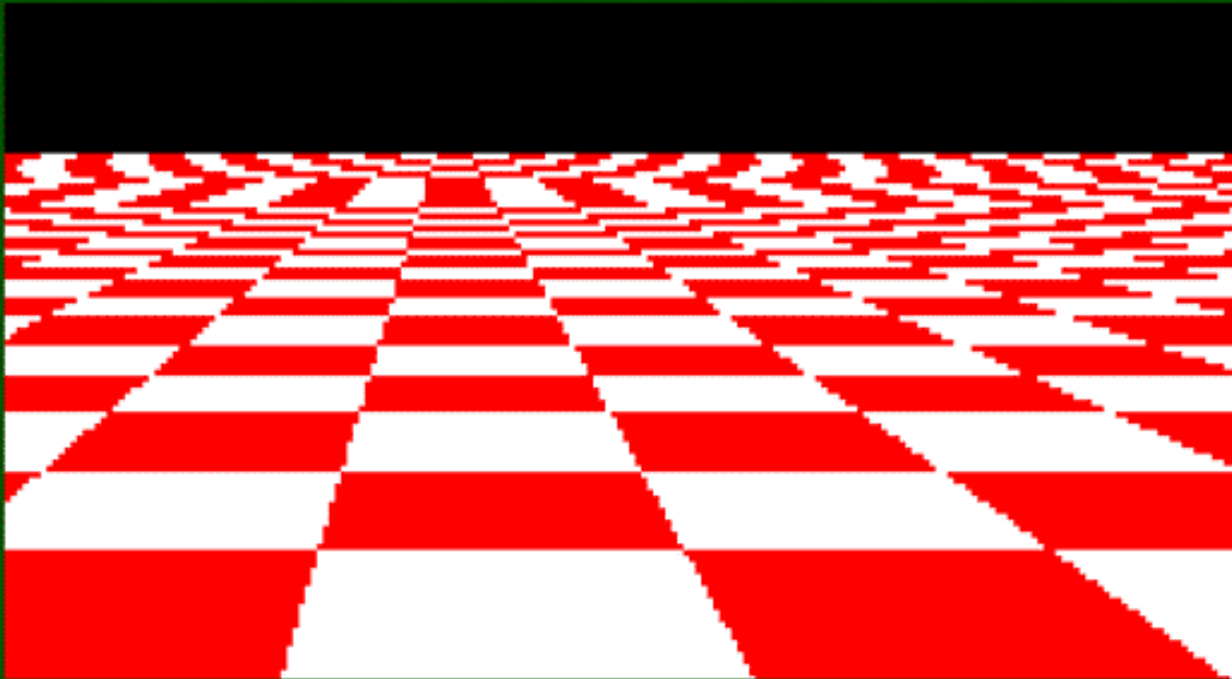


Original

Rendered

Loss of detail

Effects of aliasing



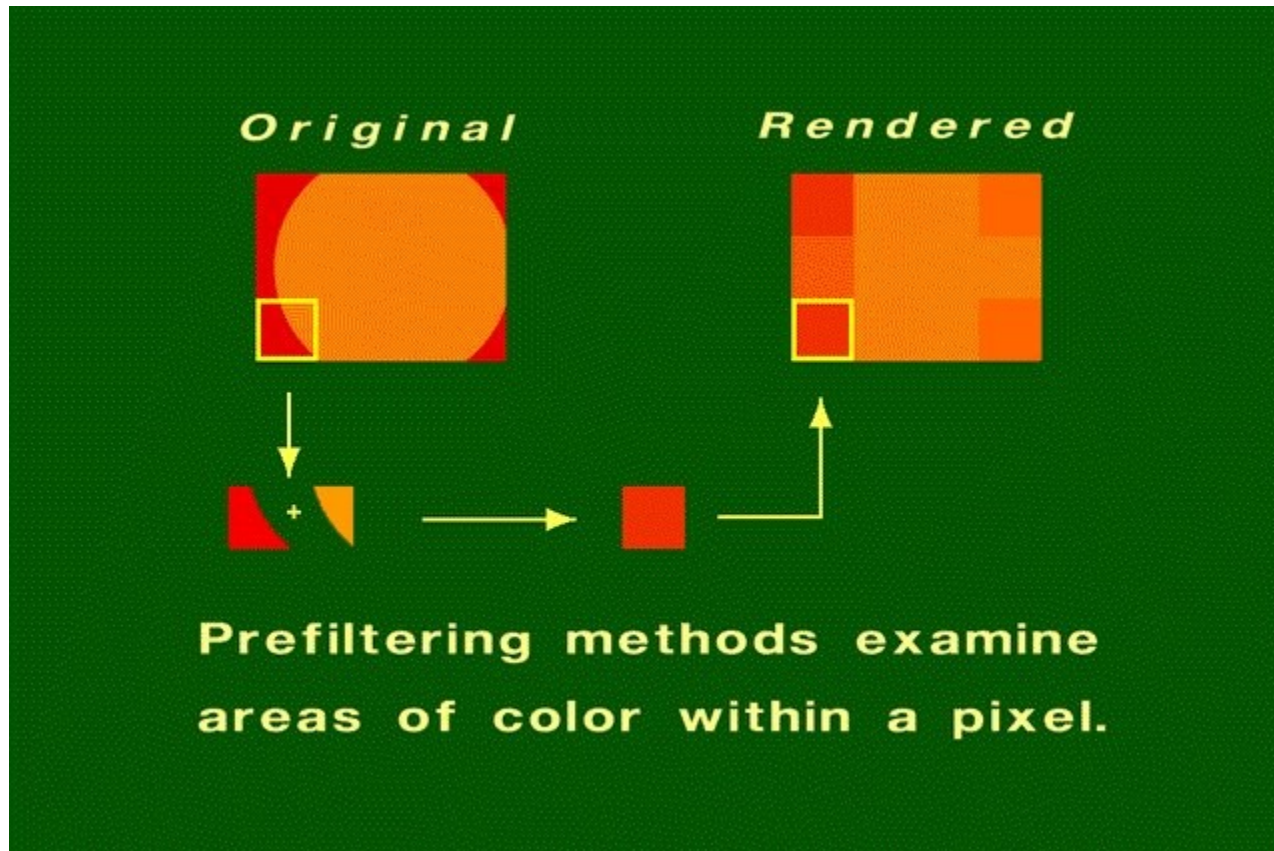
Disintegrating textures

Antialiasing

- Aim of anti-aliasing is to try to avoid the effects of aliasing as much as possible
- There are two main categories of algorithms for doing anti-aliasing
 - prefiltering: treats pixels as an area, and compute pixel color based on the overlap of the scene's objects with a pixel's area.
 - postfiltering: render the scene at higher resolution, and compute the pixel value by (weighted) average of the subpixels (supersampling)

Pre-filtering

- Pixel color is determined by how much percentage of subarea is which colour



Post-filtering

- Pixel color is determined by subsamples:
 - For each pixel, several samples are taken: usually $N=4, 9, 16$ or 25 subsamples
 - Resulting pixel “subcolors” I_i ($i=1,\dots,N$) of the subsamples are then averaged to lead to a pixel color value I

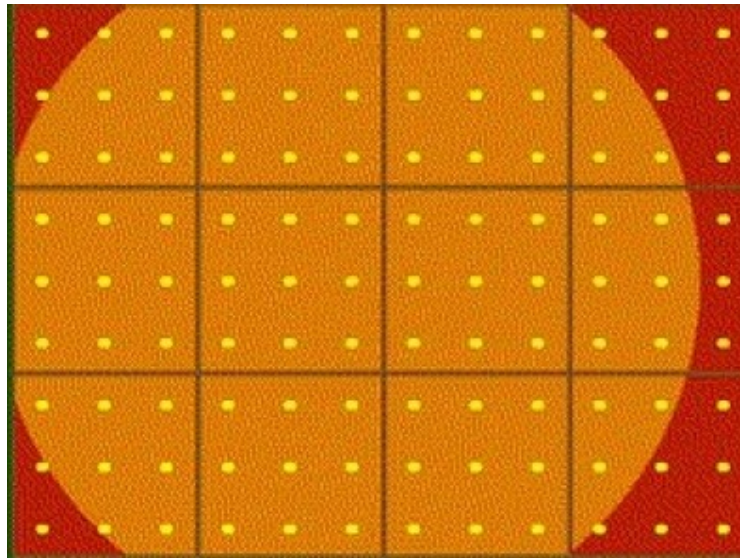
$$I = \sum_{i=1,\dots,N} I_i / N$$

- Sometimes weights w_i are used

$$I = \sum_{i=1,\dots,N} w_i I_i / N$$

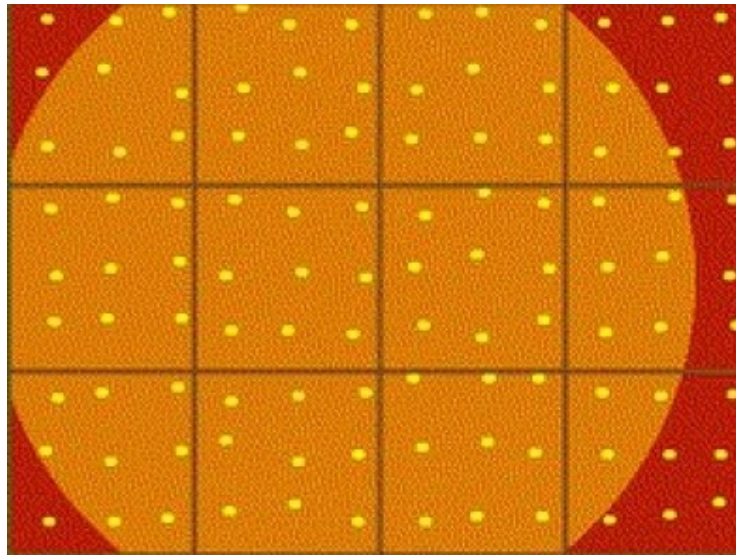
Post-filtering

- There are different ways to determine where to take the subsamples too:
 - Uniform sampling: the samples are taken on a grid (here 9 subsamples)



Post-filtering

- There are different ways to determine where to take the subsamples too:
 - Jittered sampling: the samples are centered on a grid, but random values are added to avoid aliasing



Examples



Examples



Examples



Examples



Comparison



Credits

Storyboard and Production

Rosalee Nerheim–Wolfe

Raytracing program

Cynthia Gryniewicz

David Abramoske

Artistic Director

Jenny Morlan

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