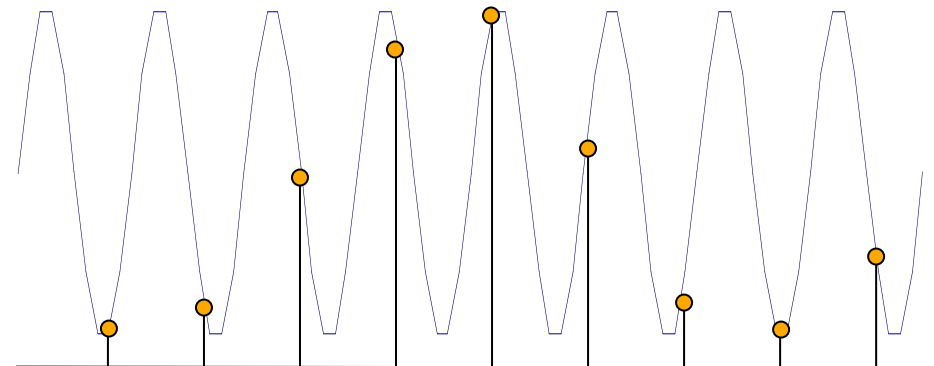
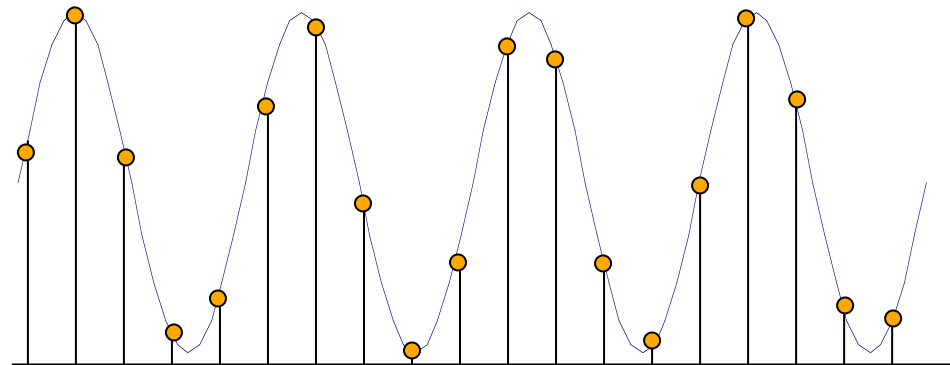


Computer Graphics: 8 - Aliasing and Antialiasing

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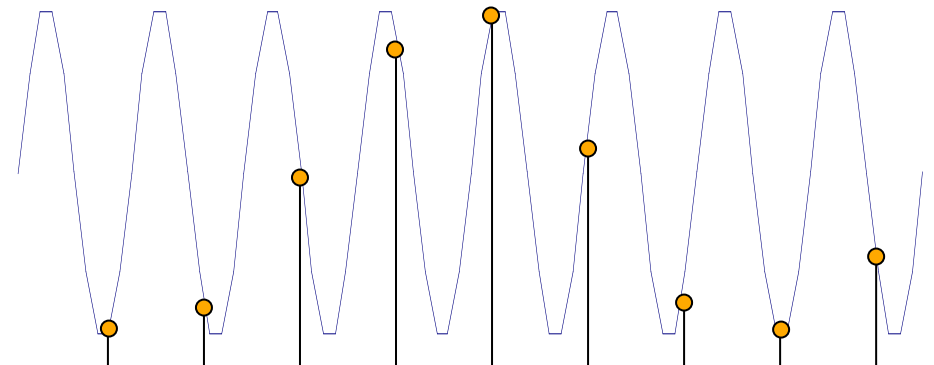
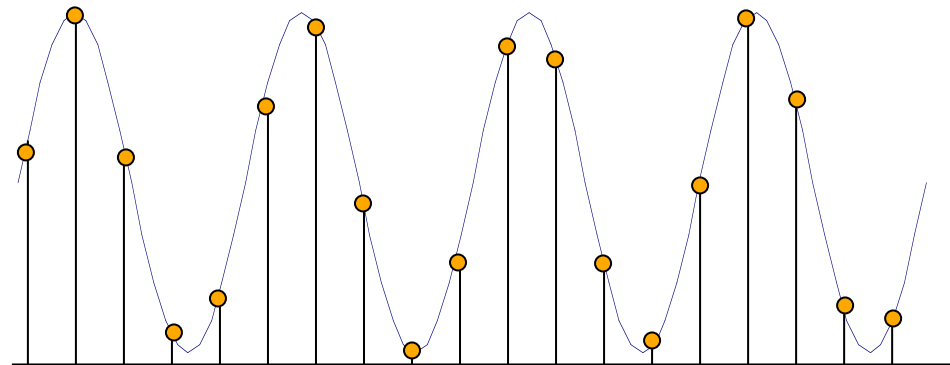
Introduction

- 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



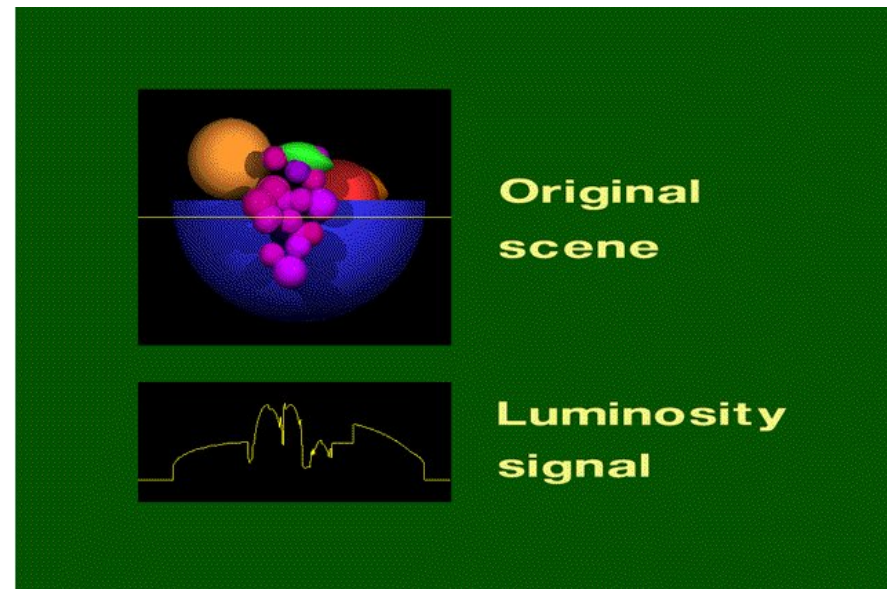
The Nyquist theorem

- 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

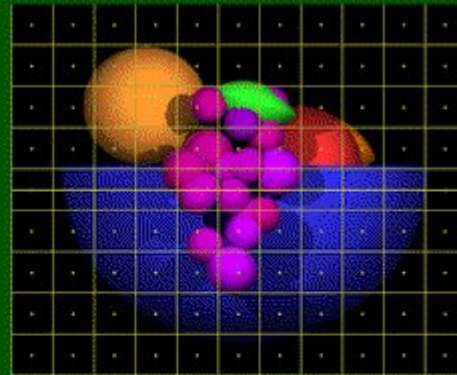


Images as functions

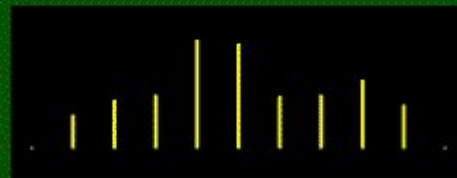
- What does this have to do with graphics?
- An Image can always be seen as a luminosity function $F(x,y)$ of values defined at the pixel centres
- As such it can be seen as the point sampling of a continuous function
- A row of pixels can be therefore seen as a function of the variable x
- Writing pixel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



Sampling images

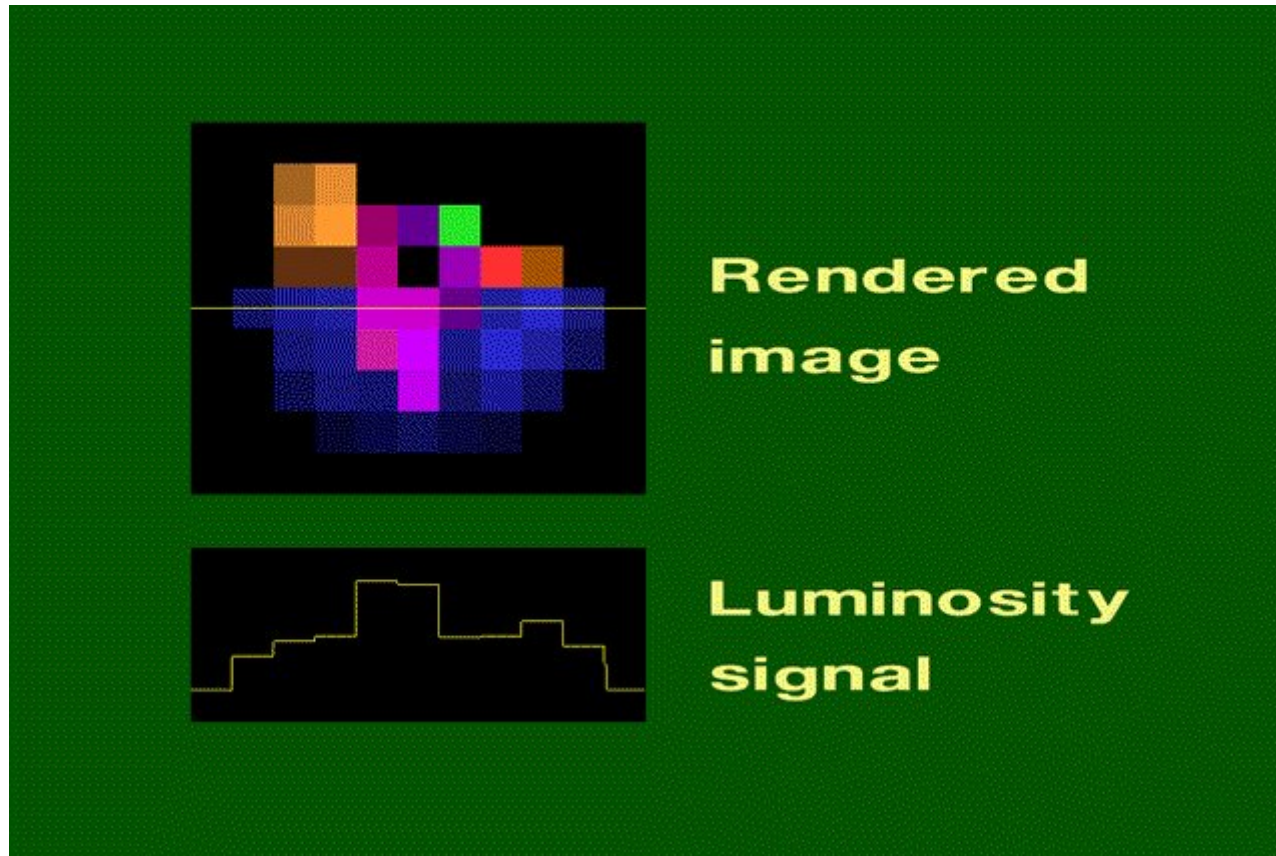


**Sampling at
pixel centers**



**Sampled
signal**

Rendering images

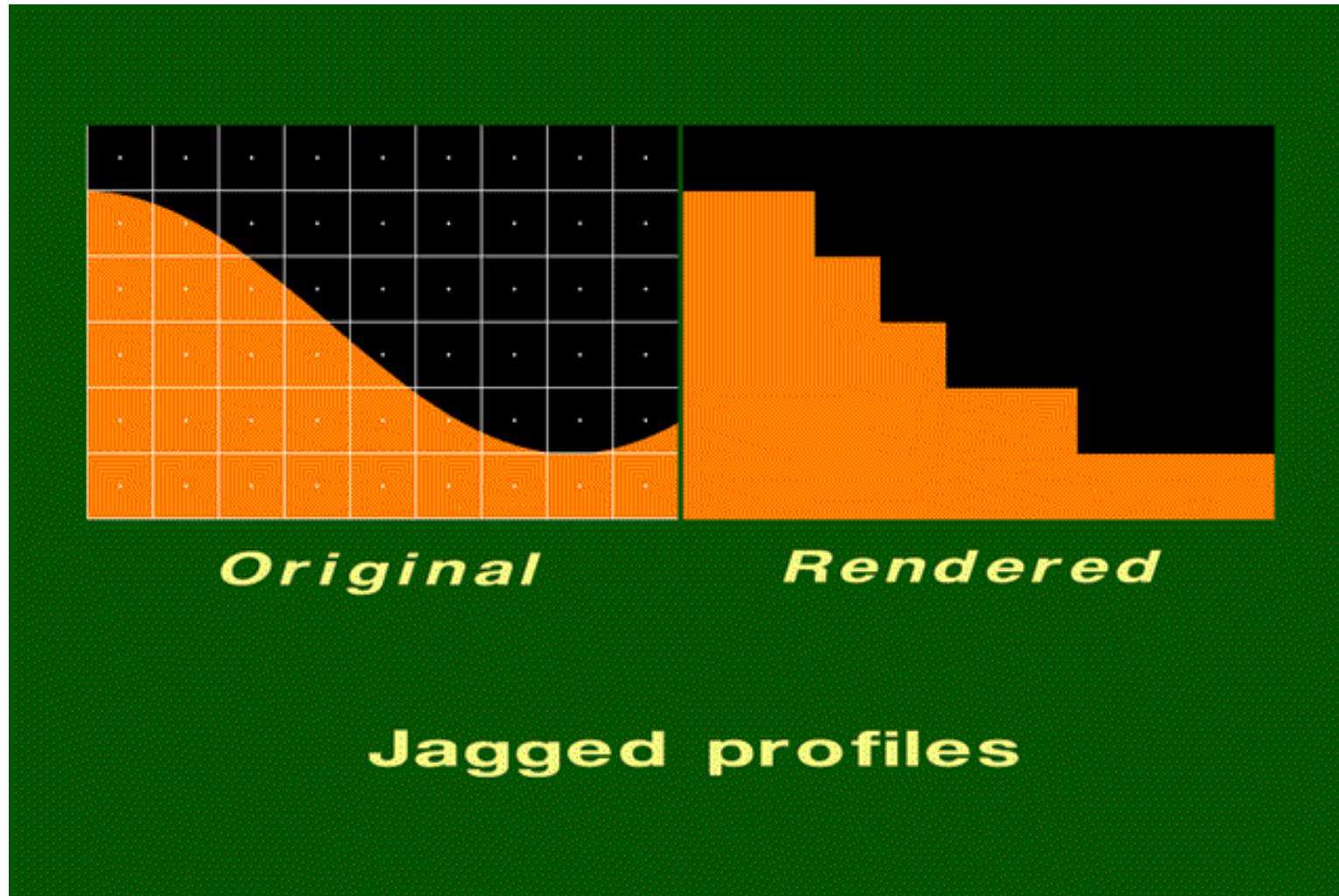


Sampling theory and graphics

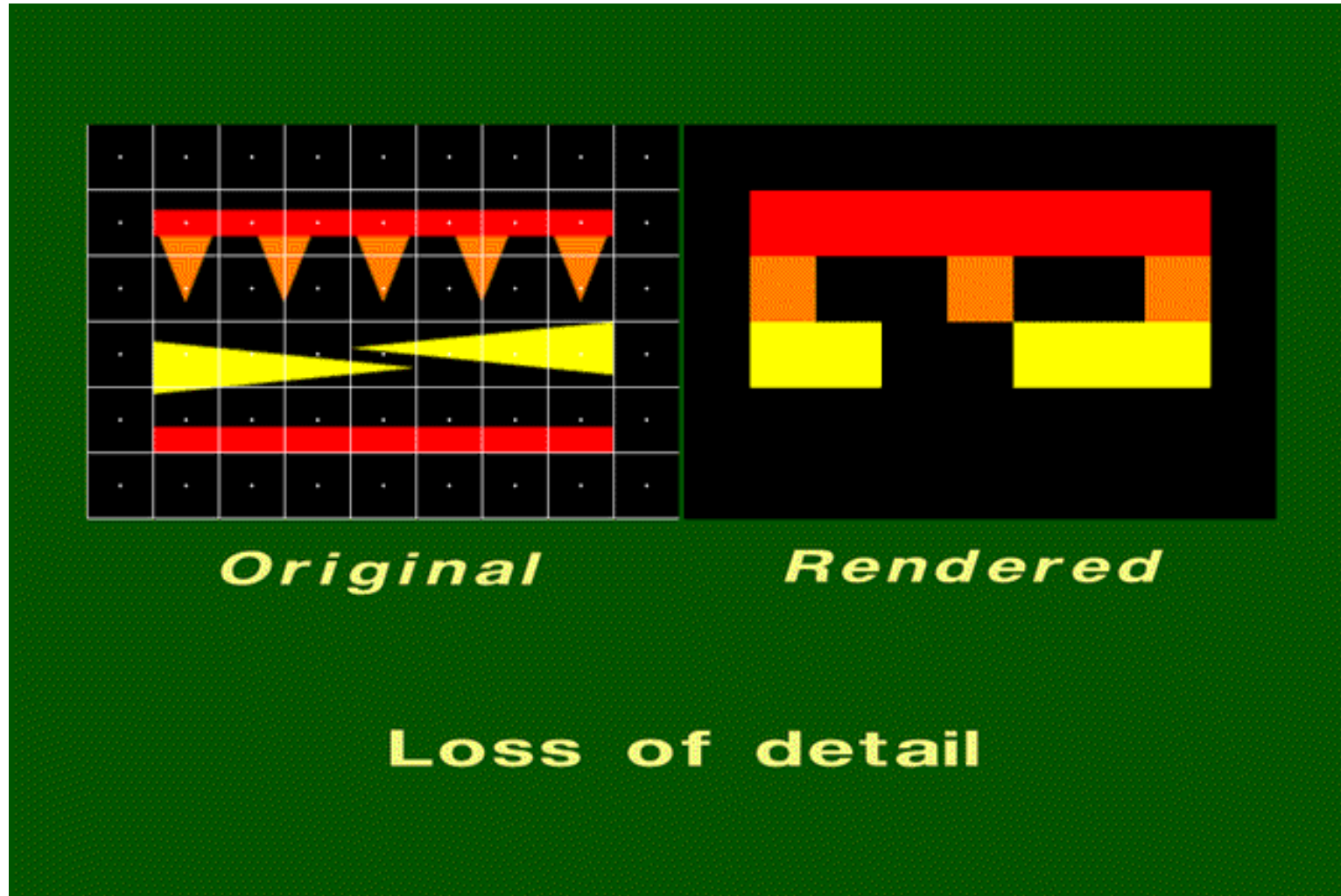
- When the pixel distance is higher than the Nyquist limit of the sampled signal frequencies, one becomes jaggies
- Jaggies are high frequencies appearing as low frequencies which produce regular patterns easy to see



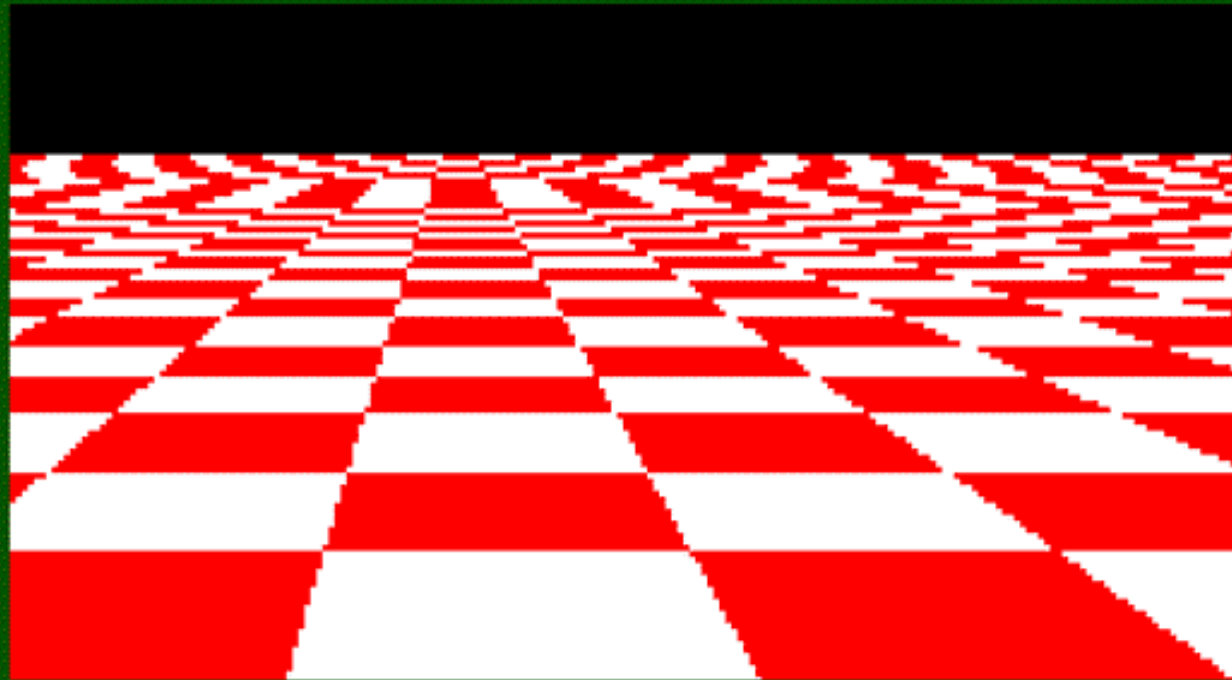
Effects of aliasing



Effects of aliasing



Effects of aliasing



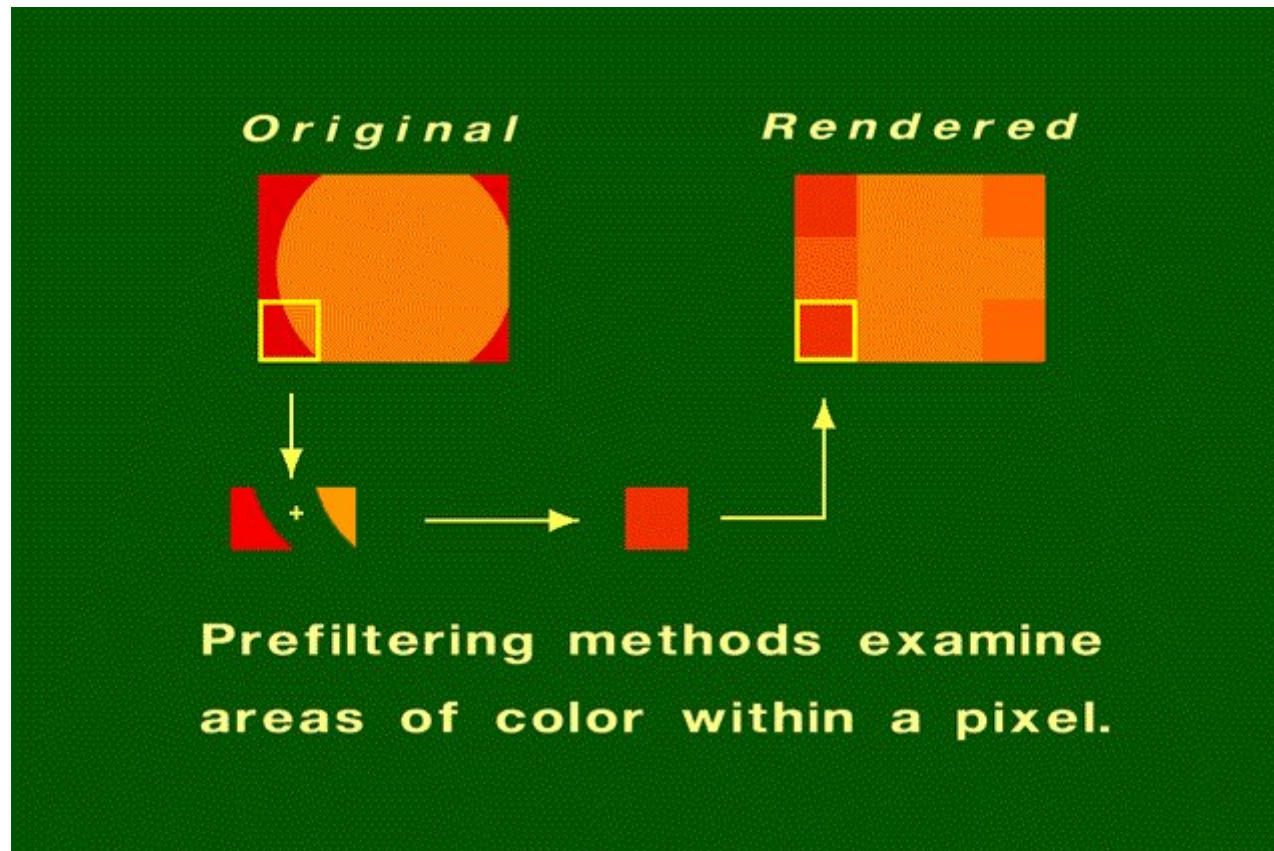
Disintegrating textures

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

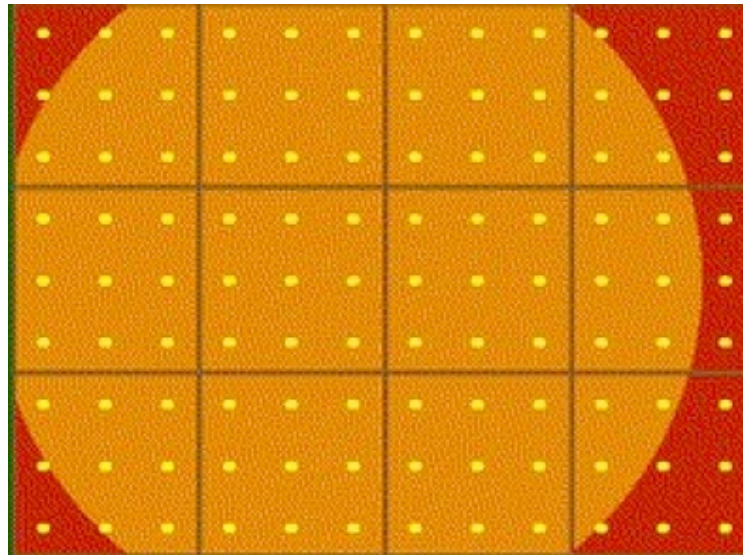
$$I = \sum_{i=1, \dots, N} I_i / N$$

- Sometimes weights w_i are used

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

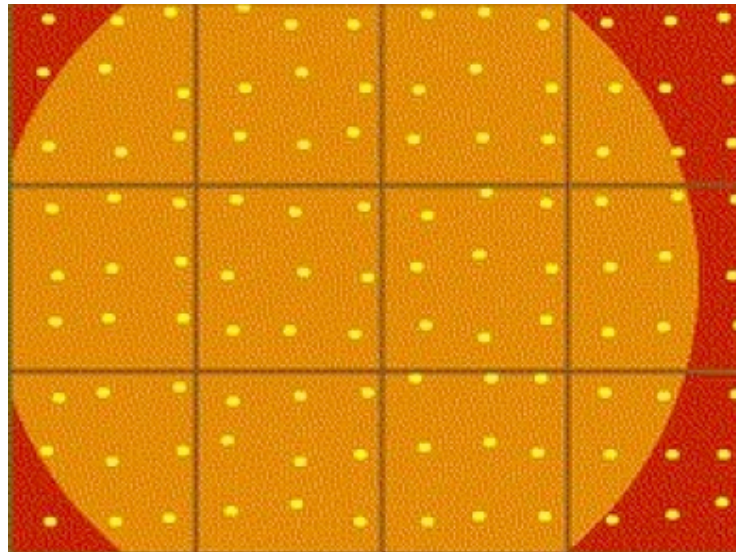
Post-filtering

- 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



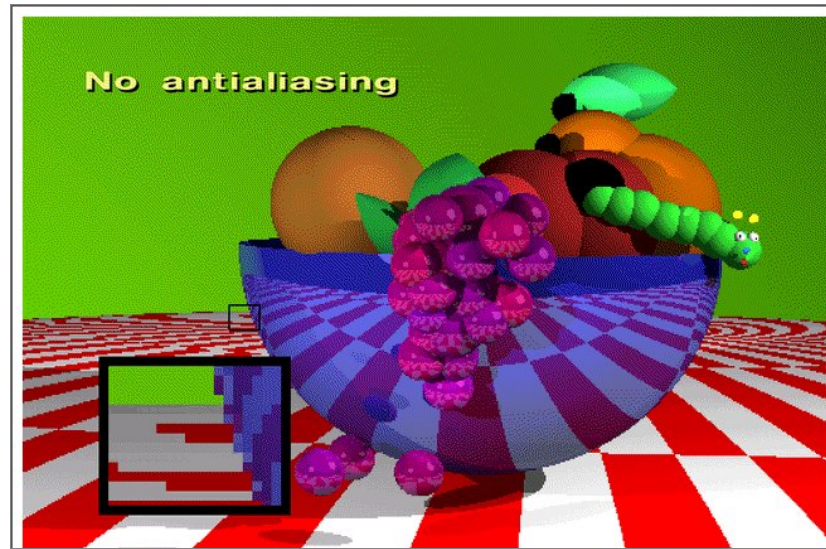
Examples



Examples



Comparison



Credits

Storyboard and Production

Rosalee Nerheim–Wolfe

Raytracing program

Cynthia Gryniewicz

David Abramoske

Artistic Director

Jenny Morlan

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