

Image Processing

Color Processing

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April 2017

Class 07b: Dithering



- Original Image

Original image: 24-bit RGB



Color Reduction

```
[im,map] = rgb2ind(rgb,8000,'nodither');  
imshow(im,map)  
title('Reduced to 8000 (max) colors')  
numColors = length(map)
```

Reduced to 8000 (max) colors



Color Reduction

```
[im,map] = rgb2ind(rgb,4000,'nodither');  
imshow(im,map)  
title('Reduced to 4000 (max) colors')  
numColors = length(map)
```

Reduced to 4000 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,2000,'nodither');  
imshow(im,map)  
title('Reduced to 2000 (max) colors')  
numColors = length(map)
```

Reduced to 2000 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,1000,'nodither');  
imshow(im,map)  
title('Reduced to 1000 (max) colors')  
numColors = length(map)
```

Reduced to 1000 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,500,'nodither');  
imshow(im,map)  
title('Reduced to 500 (max) colors')  
numColors = length(map)
```

Reduced to 500 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,200,'nodither');  
imshow(im,map)  
title('Reduced to 200 (max) colors')  
numColors = length(map)
```

Reduced to 200 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,100,'nodither');  
imshow(im,map)  
title('Reduced to 100 (max) colors')  
numColors = length(map)
```

Reduced to 200 colors



Color Reduction

```
[im,map] = rgb2ind(rgb,50,'nodither');  
imshow(im,map)  
title('Reduced to 50 (max) colors')  
numColors = length(map)
```

Reduced to 50 colors



Color Reduction

Original image: 24-bit RGB



Reduced to 200 colors



Reduced to 200 colors



Reduced to 50 colors



Color Reduction with Dithering

```
[im,map] = rgb2ind(rgb,50);  
imshow(im,map)  
title('Only 50 colors dithered (default)')  
numColors = length(map)
```

Only 50 colors dithered (default)



Color Reduction with Dithering

Original image: 24-bit RGB



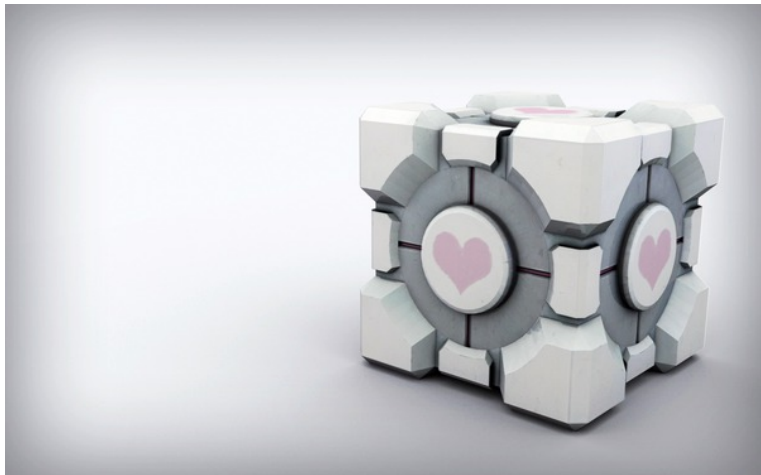
Reduced to 50 colors



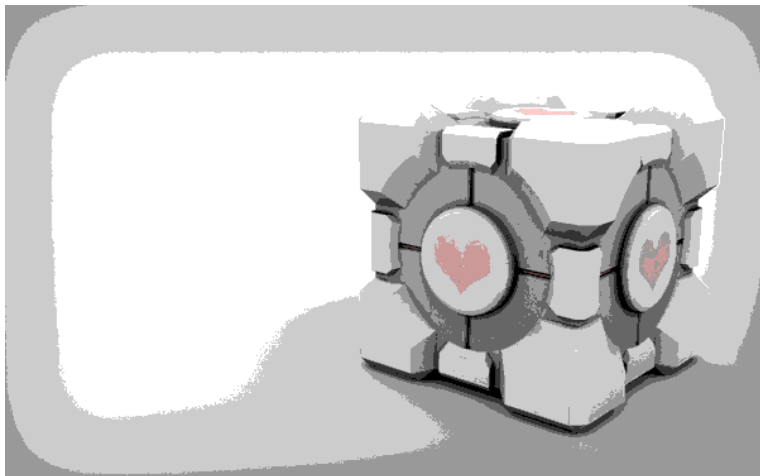
Only 50 colors dithered (default)



Original

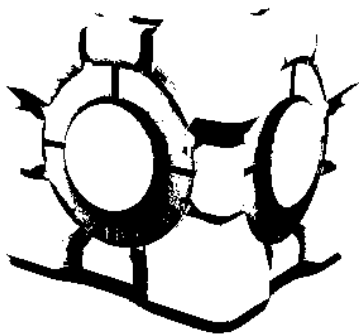


websafe

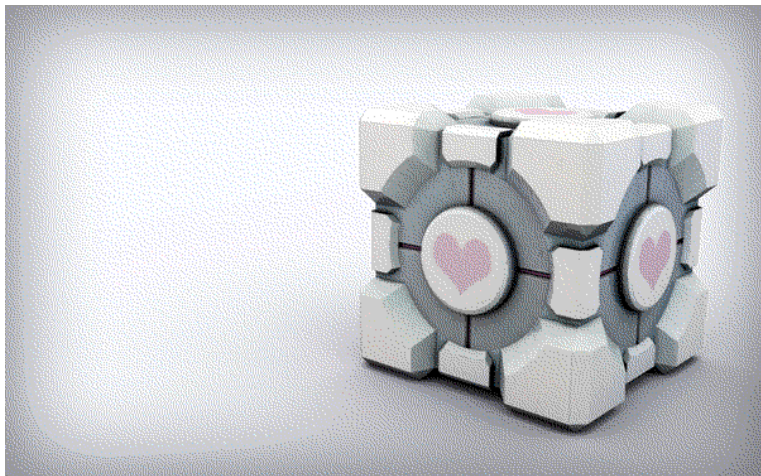


More Examples ...

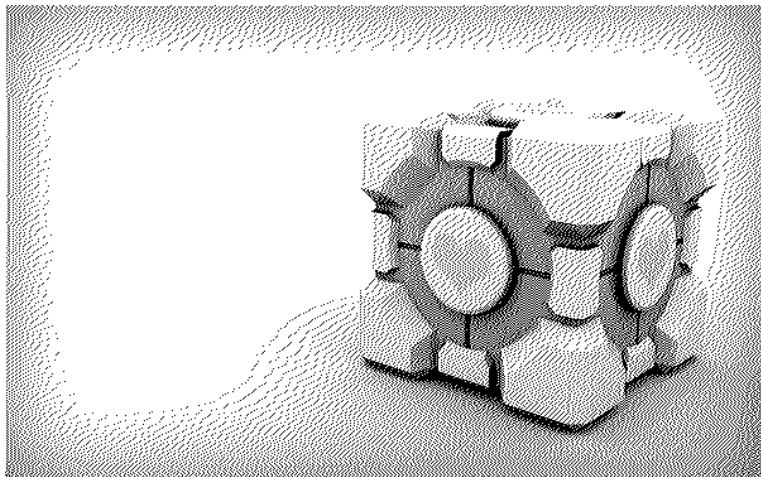
black-and-white (printing)



websafe with dithering



preto-e-branco (impressão) com dithering



- error diffusion – random addition of noise to the quantized image



- error diffusion – random addition of noise to the quantized image

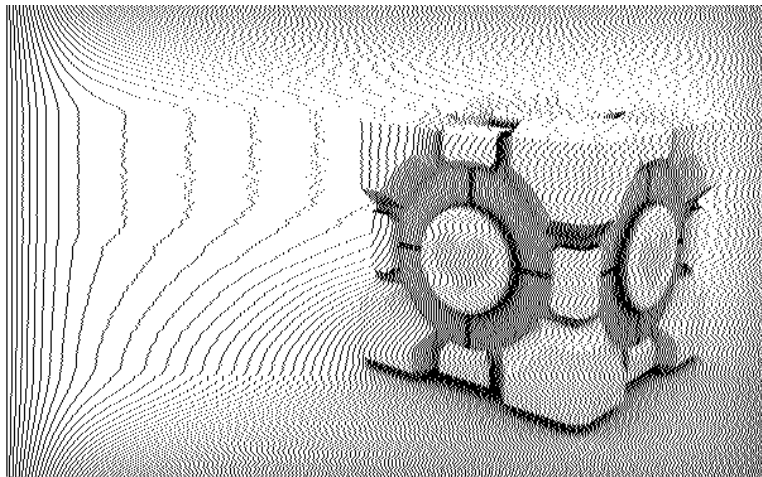


- converting the image to binary, 92 is approximated to 0.



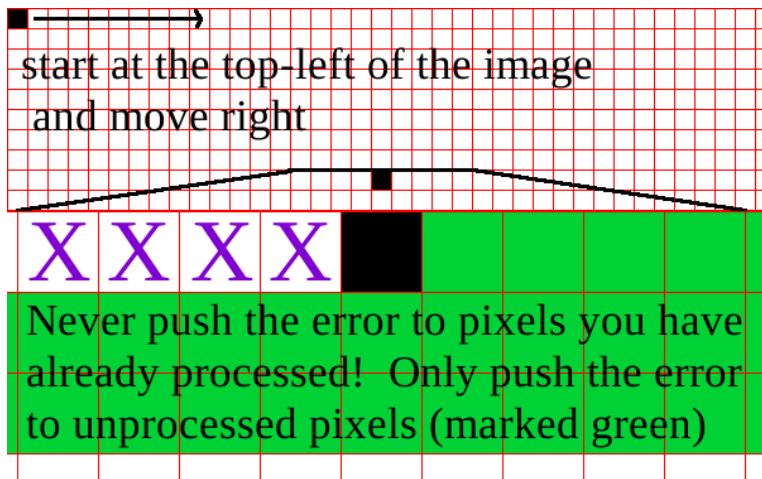
- With dithering, the pixel would be quantized as 0, but the error between the real and quantized values are stored ($e = 96$).
- When the next pixel is quantized, this error is added. If the next pixel is also 96, it is adjusted to 192, what makes it closer to 255(white).
- The error is now -63. Observe that the error is 'difused' among the lines of the image.

1-D dithering



Dithering

2-D dithering



Floyd-Steinberg Dithering

- One of the most famous 2-D dithering algorithms;
- Error Diffusion Pattern:

	X	7
3	5	1

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- The error is divided by 1/16.

$$\begin{array}{ccc} & X & 7/16 \\ 3/16 & 5/16 & 1/16 \end{array}$$

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- Ex: Region full of pixels with value 96. Error Diffusion is performed in the region.

$$\begin{array}{ccc} & X & +42 \\ +18 & +30 & +6 \end{array}$$

Floyd-Steinberg Dithering

- One of the most famous 2-D dithering algorithms;
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$$\begin{array}{ccc} & X & 7 \\ 3 & 5 & 1 \end{array}$$

- The error is divided by $1/16$.

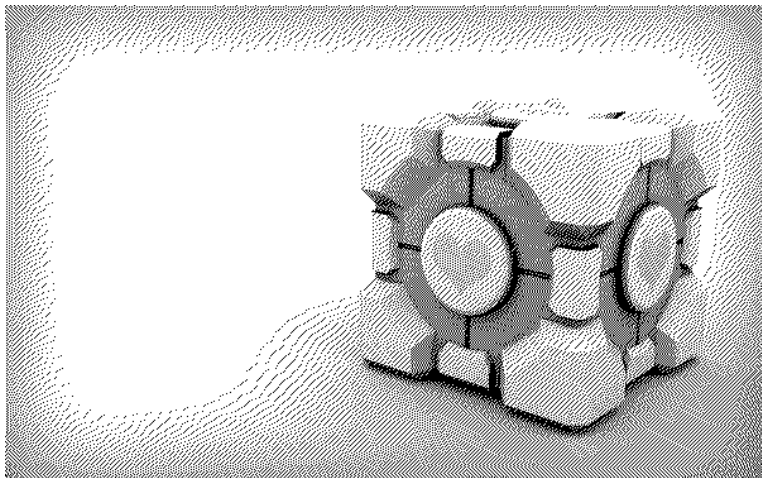
$$\begin{array}{ccc} & X & 7/16 \\ 3/16 & 5/16 & 1/16 \end{array}$$

- Ex: Region full of pixels with value 96. Error Diffusion is performed in the region.

$$\begin{array}{ccc} & X & +42 \\ +18 & +30 & +6 \end{array}$$

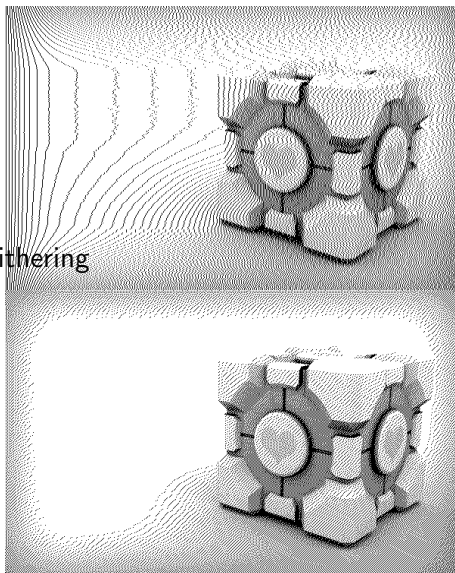
- Values $1/3/5/7$ are used to distribute the error. They were chosen because they create a checkboard pattern.

Floyd-Steinberg Dithering



Floyd-Steinberg Dithering

2-D simple



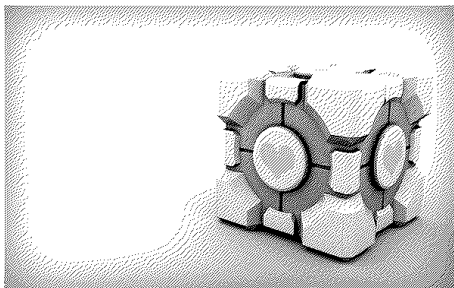
Floyd-Steinberg Dithering

- Error Diffusion Pattern:

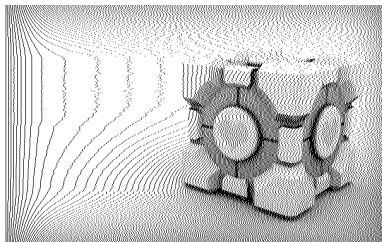
				X	7
	3	5	7	5	3
	1	3	5	3	1

- Error Diffusion Pattern:

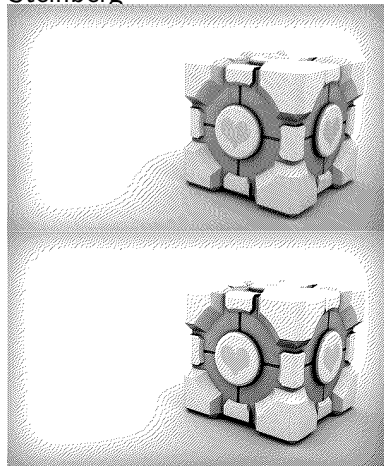
			X	7
3	5	7	5	3
	1	3	5	3
				1
- The error is divided by 1/48.
- Better error distribution, better result!
- But, 48 is not a power of 2 – we cannot use bit-shifting.
- More memory.



1-D



Floyd-Steinberg



Jarvis, Judice, and Nink

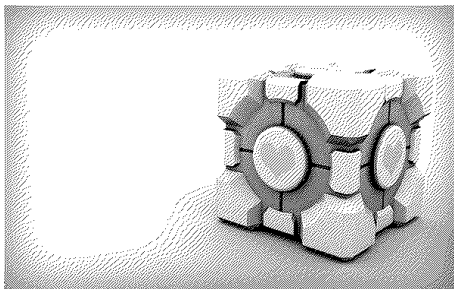
- Error Diffusion Pattern:

			x	8	4
2	4	8	4	2	
1	2	4	2	1	

Stucki Dithering

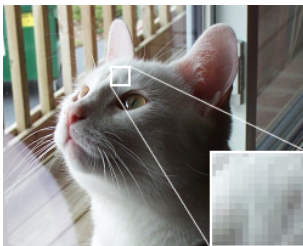
- Error Diffusion Pattern:

			×	8	4
2	4	8	4	2	
1	2	4	2	1	
- The error is divided by $1/42$.
- Although 42 is not a power of 2, the difference is – we can use bit-shifting.

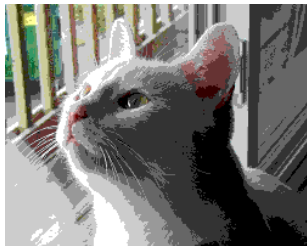


Color Reduction

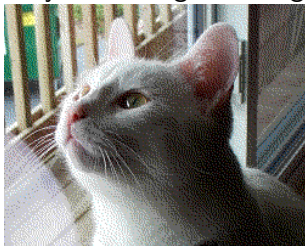
original



websafe colors - no dithering

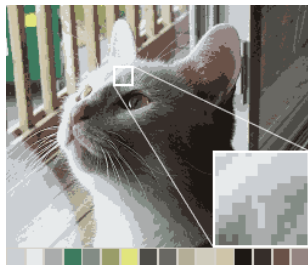


FloydSteinberg dithering

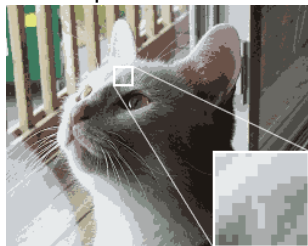


Color Reduction

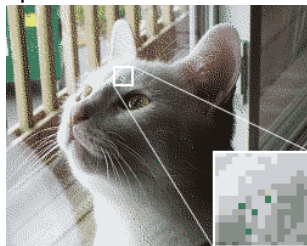
16 optimized colors



16 optimized colors

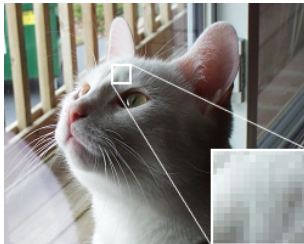


16 optimized colors + dithering

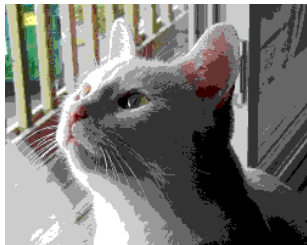


Color Reduction

original



websafe colors - no dithering



256 optimized colors + dithering

