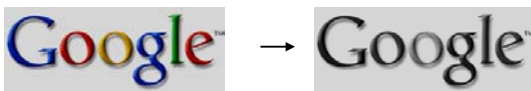
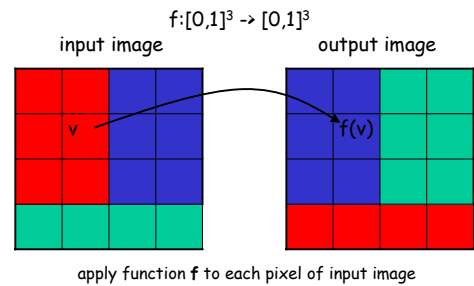


digital image processing

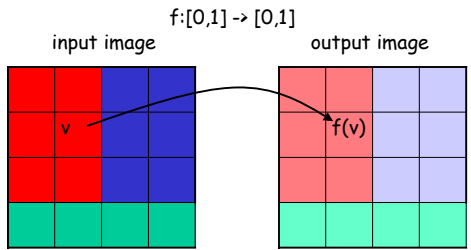
- simple pixel modification
- interpolation/extrapolation
- compositing
- convolution
- dithering
- warping
- morphing
- misc. effects

- **simple pixel modification**
- interpolation/extrapolation
- compositing
- convolution
- dithering
- warping
- morphing
- misc. effects



$$f(r,g,b) = .3r + .59g + .11b$$

simple pixel modification

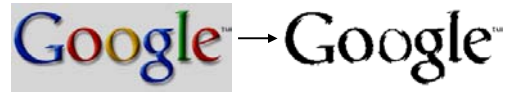


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threshold



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threshold

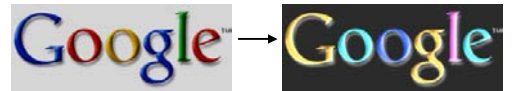
if $v > t$ then $f(v)=1$
else $f(v)=0$

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invert



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invert

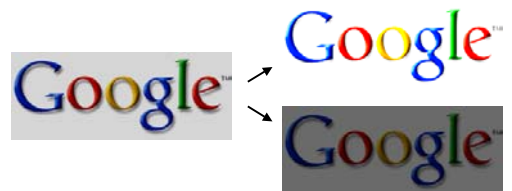
$f(v) = 1-v$

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brighten/darken



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brighten/darken

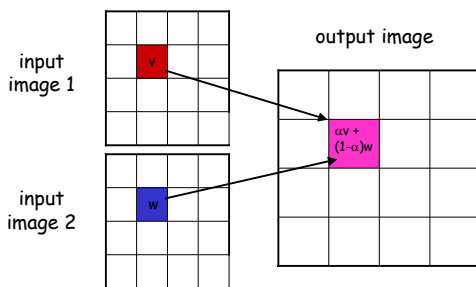
$$f(v) = \alpha v \text{ for } \alpha \geq 0$$

clamp to [0,1]

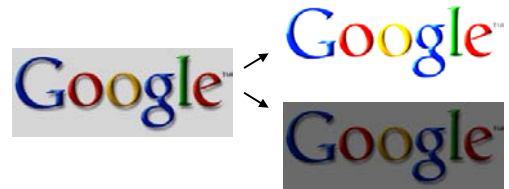
types of techniques

- simple pixel modification
- **interpolation/extrapolation**
- compositing
- convolution
- dithering
- warping
- morphing
- non-photo-realistic effects

interpolation/extrapolation



interpolation/extrapolation



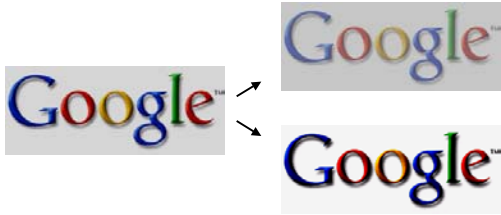
brighten/darken

interpolate/extrapolate image with

invert

interpolate/extrapolate image with

change contrast



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change contrast

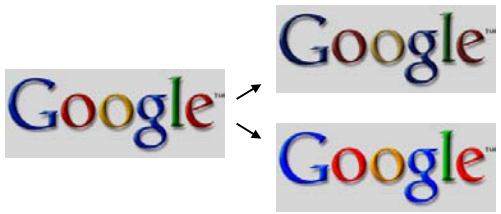
interpolate/extrapolate image with

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change saturation



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change saturation

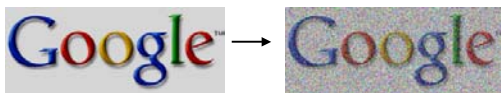
interpolate/extrapolate image with

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noisify



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noisify

interpolate/extrapolate with

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type of techniques

- simple pixel modification
- interpolation/extrapolation
- **compositing**
- convolution
- dithering
- warping
- morphing
- misc. effects

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compositing



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compositing

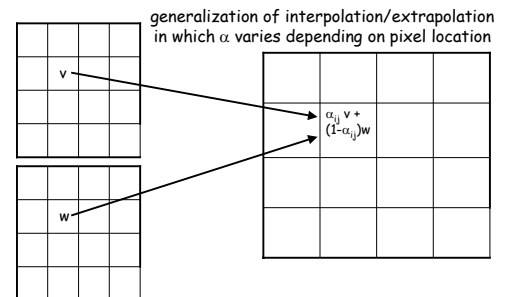


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compositing



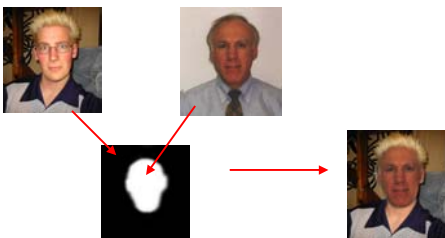
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compositing

typically $\alpha \in [0,1]$ so the array of α values can be represented by a single channel image called a *mask*



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type of techniques

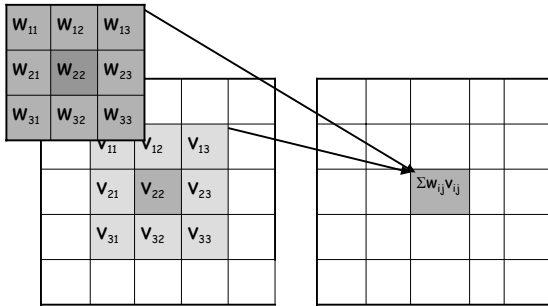
- simple pixel modification
- interpolation/extrapolation
- compositing
- **convolution**
- dithering
- warping
- morphing
- misc. effects

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convolution

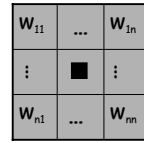


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kernel



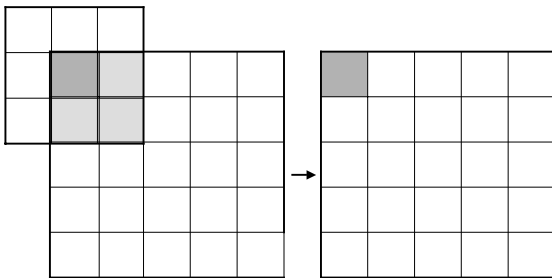
n odd

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boundaries?

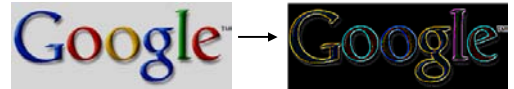


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edge detect



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edge detect kernel

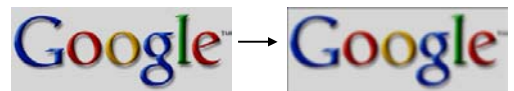
-1/8	-1/8	-1/8
-1/8	1	-1/8
-1/8	-1/8	-1/8

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blur



why blur?

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anti-aliasing



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3x3 box blur

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

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nXn box blur

w	...	w
⋮	■	⋮
w	...	w

$$w=1/n^2$$

why is it important that the sum of the weights is 1?

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separability

a kernel is separable if $W_{ij}=w_i w_j$

is the box filter separable?

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box blur vs. triangle blur



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3x3 triangle blur

1/16	1/8	1/16
1/8	1/4	1/8
1/16	1/8	1/16

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separability

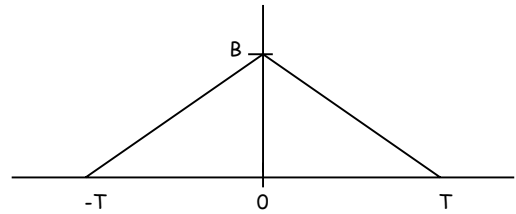
1/4	1/16	1/8	1/16
1/2	1/8	1/4	1/8
1/4	1/16	1/8	1/16
	1/4	1/2	1/4

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triangle function

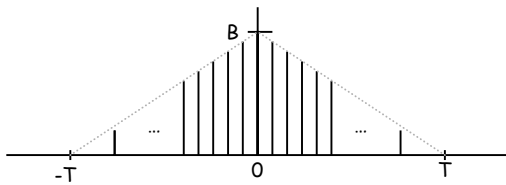


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discrete triangle



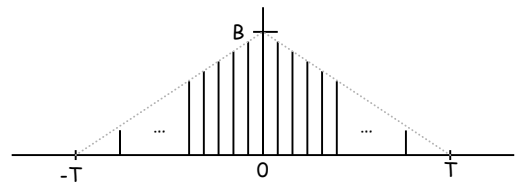
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normalized, discrete triangle

1. $T = (n+1)/2$ gives n non-zero samples
2. $\sum_{j=-T}^T f(j) = 1$ provided $B = 2/(n+1)$

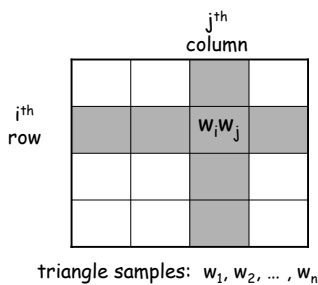


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triangle blur filter



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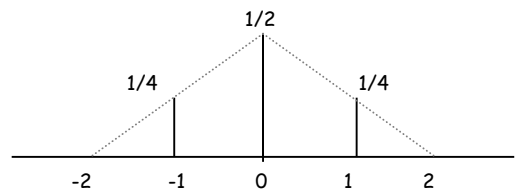
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example: $n=3$

$$T = (n+1)/2 = 2$$

$$B = 2/(n+1) = 1/2$$



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3x3 triangle blur filter

1/4	1/16	1/8	1/16
1/2	1/8	1/4	1/8
1/4	1/16	1/8	1/16
	1/4	1/2	1/4

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box, triangle and gaussian blurs



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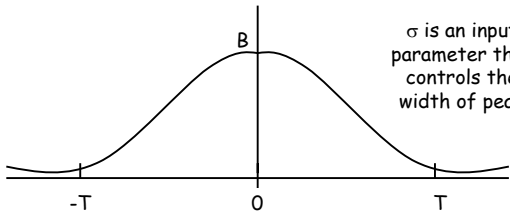
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gaussian function

$$f(x) = Be^{-x^2/\sigma^2}$$

σ is an input parameter that controls the width of peak



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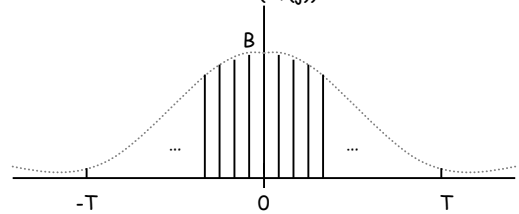
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normalized, discrete version

$$T = (n+1)/2 \text{ gives } n \text{ samples}$$

$$B = 1/(\sum f(j))$$

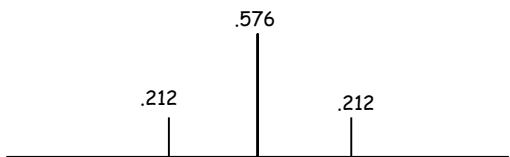


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example: $n=3, \sigma=1$



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3x3 gaussian blur, $\sigma = 1$

.212	.045	.122	.045
.576	.122	.332	.122
.212	.045	.122	.045
	.212	.576	.212

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type of techniques

- simple pixel modification
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