Image Smoothing

Neighbourhood Operations

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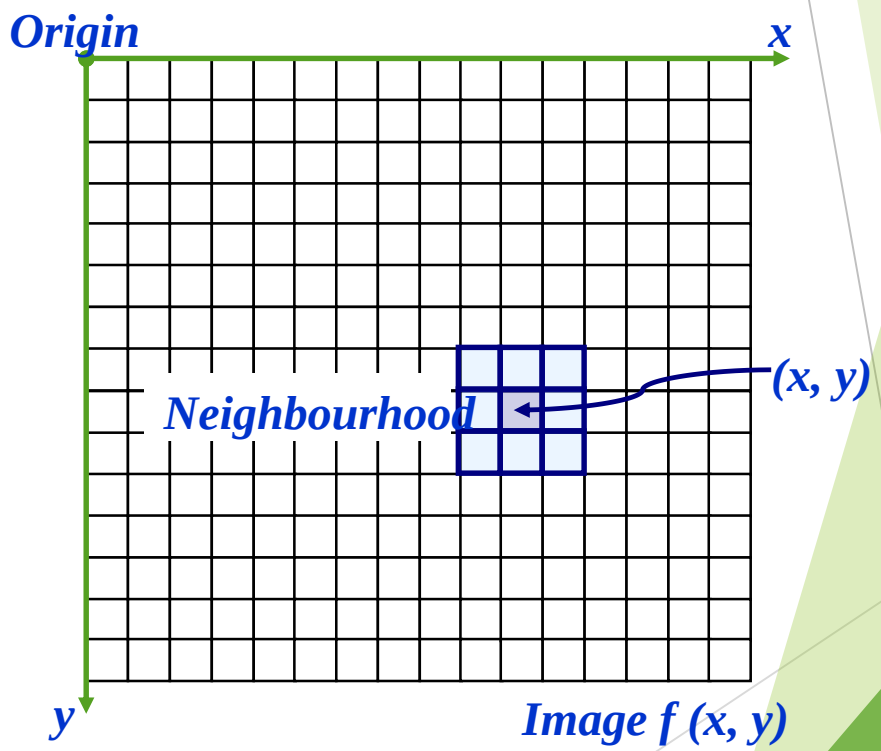
- Neighbourhood are mostly a rectangle around a centre pixel
- This rectangle can be of any size

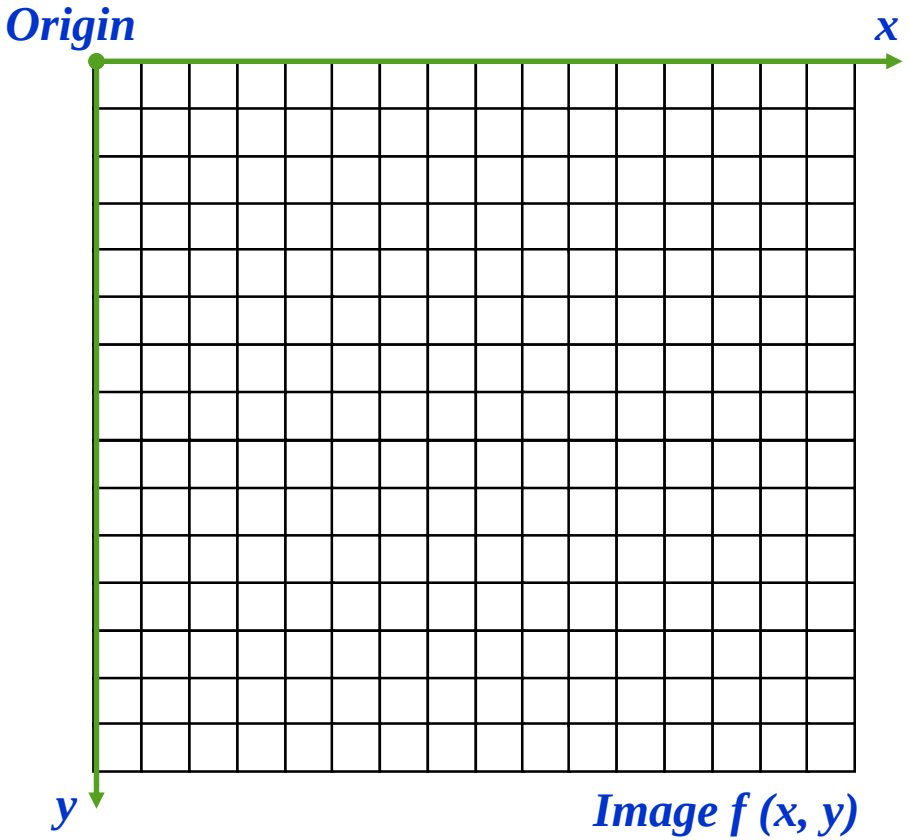


Simple Neighbourhood Operations

Simple Neighbourhood Operations

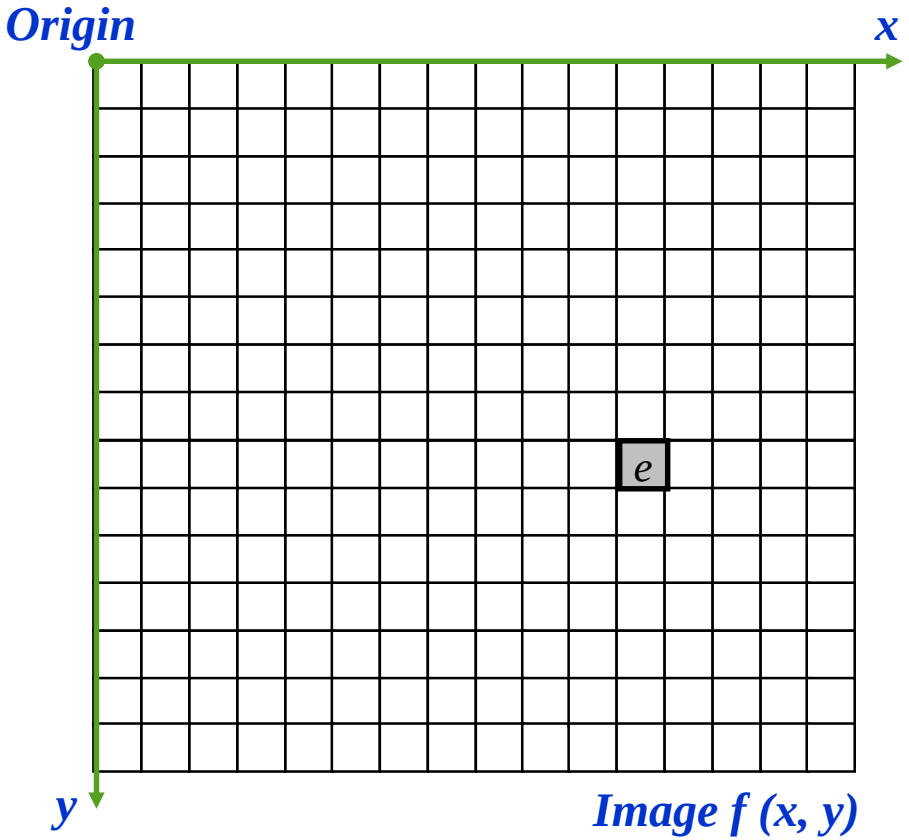
- These include:
  - **Min:** Set the pixel value to the minimum in the neighbourhood
  - **Max:** Set the pixel value to the maximum in the neighbourhood
  - **Mean:** Set the pixel value to the neighbourhood mean
  - **Weighted Mean:** Set pixel value to weighted neighbourhood mean

The Spatial Filtering Process



The above process is repeated for each and every pixel to get filtered image

The Spatial Filtering Process



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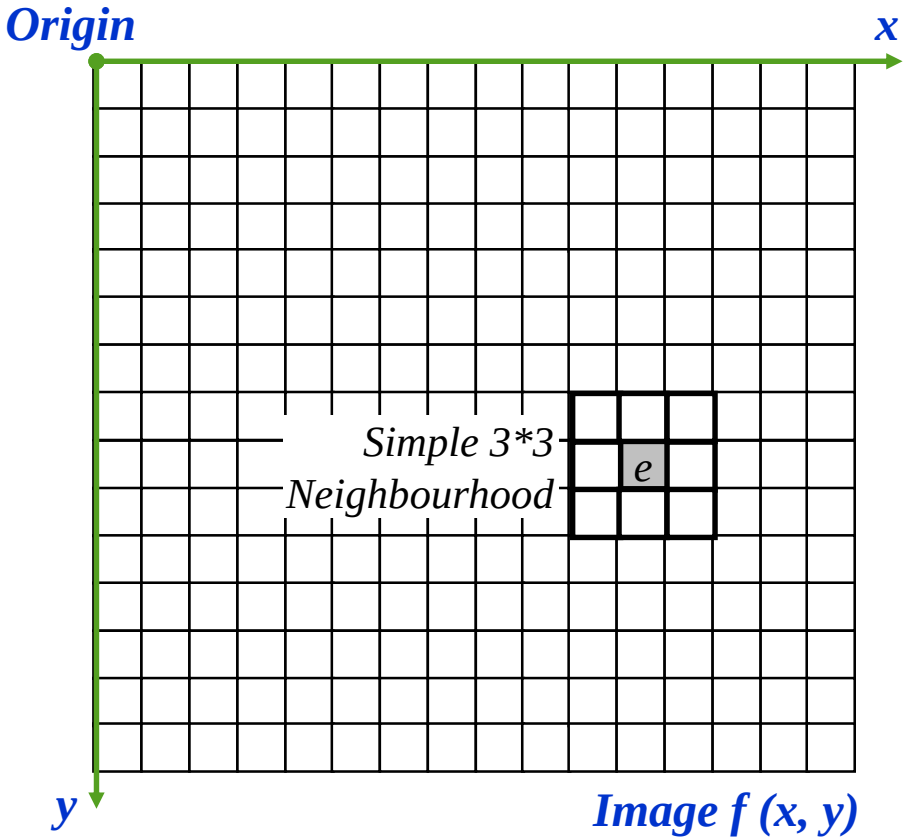

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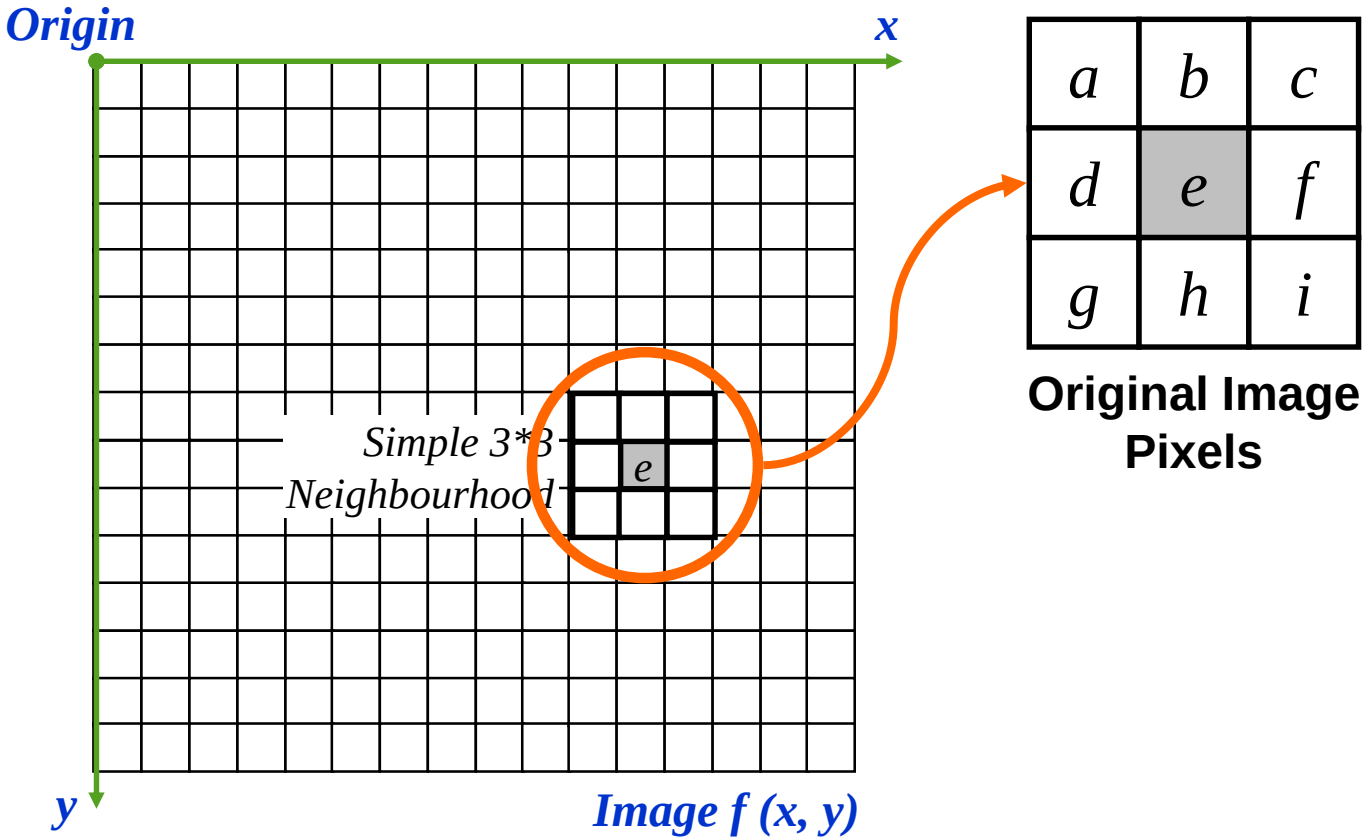

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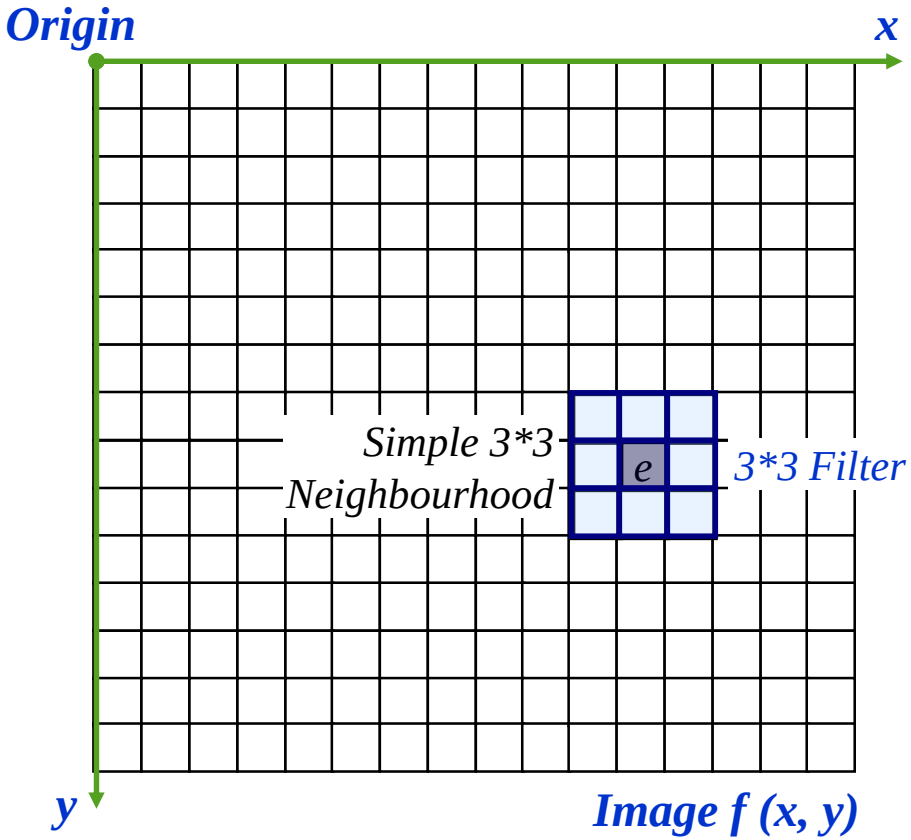
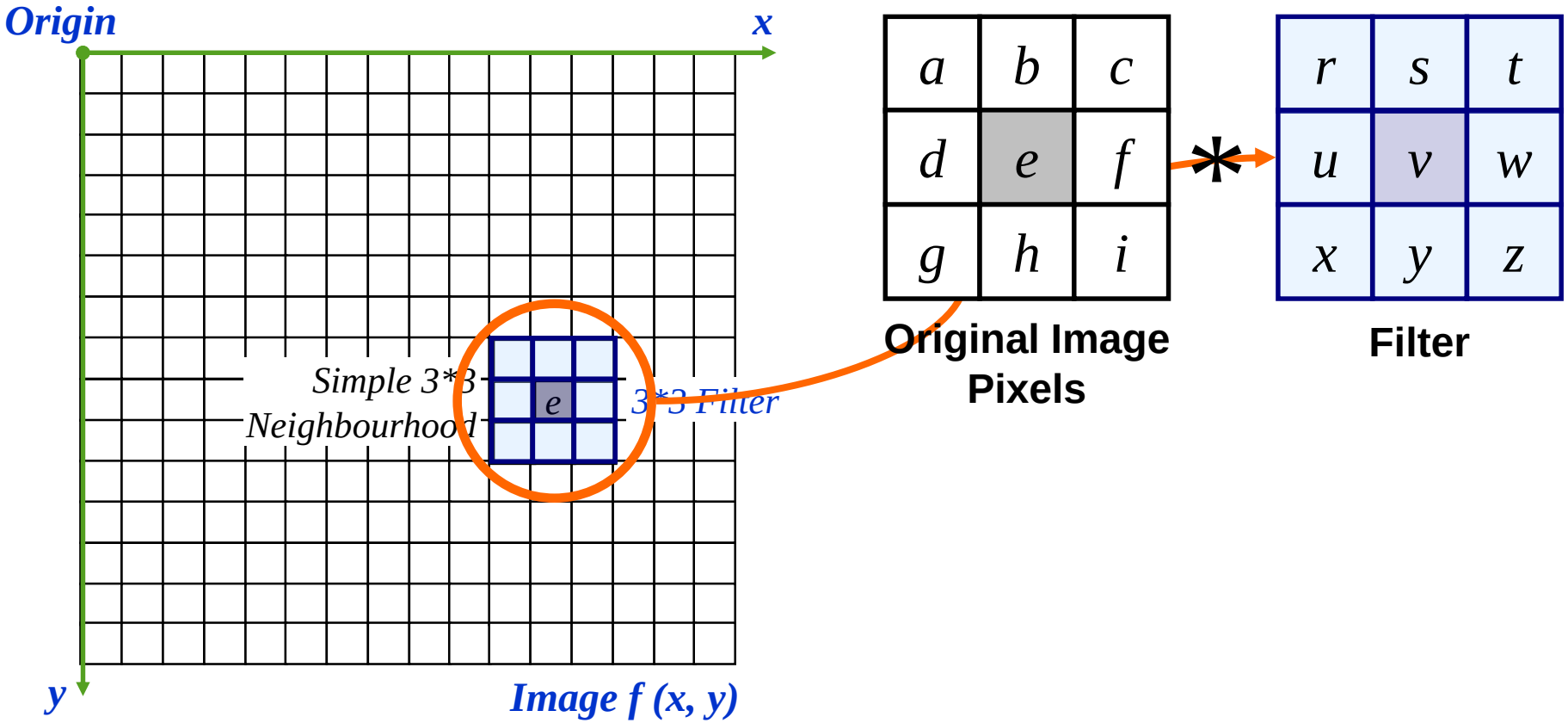


a	*b*	*c*
d	*e*	*f*
g	*h*	*i*

Original Image Pixels

The above process is repeated for each and every pixel to get filtered image

The Spatial Filtering Process



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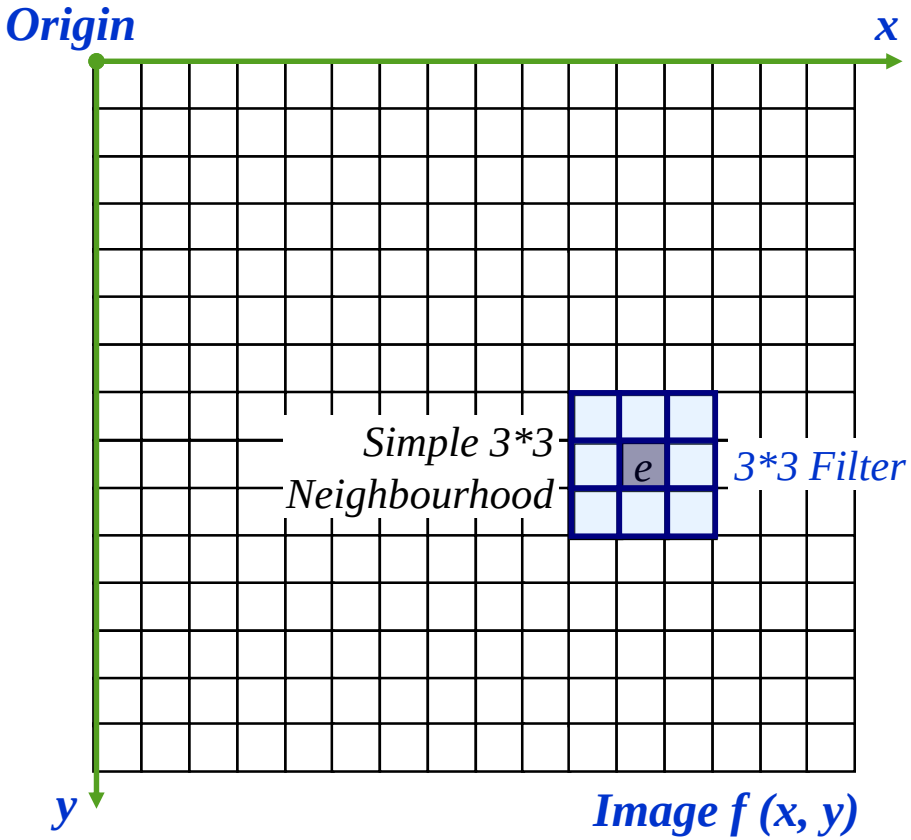

a	b	c
d	e	f
g	h	i

Original Image Pixels

$*$

r	s	t
u	v	w
x	y	z

Filter

$$e_{processed} = v*e + r*a + s*b + t*c + u*d + w*f + x*g + y*h + z*i$$

The above process is repeated for each and every pixel to get filtered image

Smoothing Spatial Filters

Smoothing Spatial Filters

- One of the simplest spatial filtering operations we can perform is a un-weighted smoothing process
  - Simply average all of the pixels in a neighbourhood around a central value
  - Especially useful in removing noise from images but may lead to edge blurring
  - Also useful for highlighting gross detail

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Simple Averaging Filter

$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$

Image Smoothing Example

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- The image at the top left is an original image of size 500*500 pixels

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Image Smoothing Example

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- The subsequent images show the image after filtering with an un-weighted averaging filter of increasing rectangular filter sizes
  - 3, 5, 9, 15 and 35

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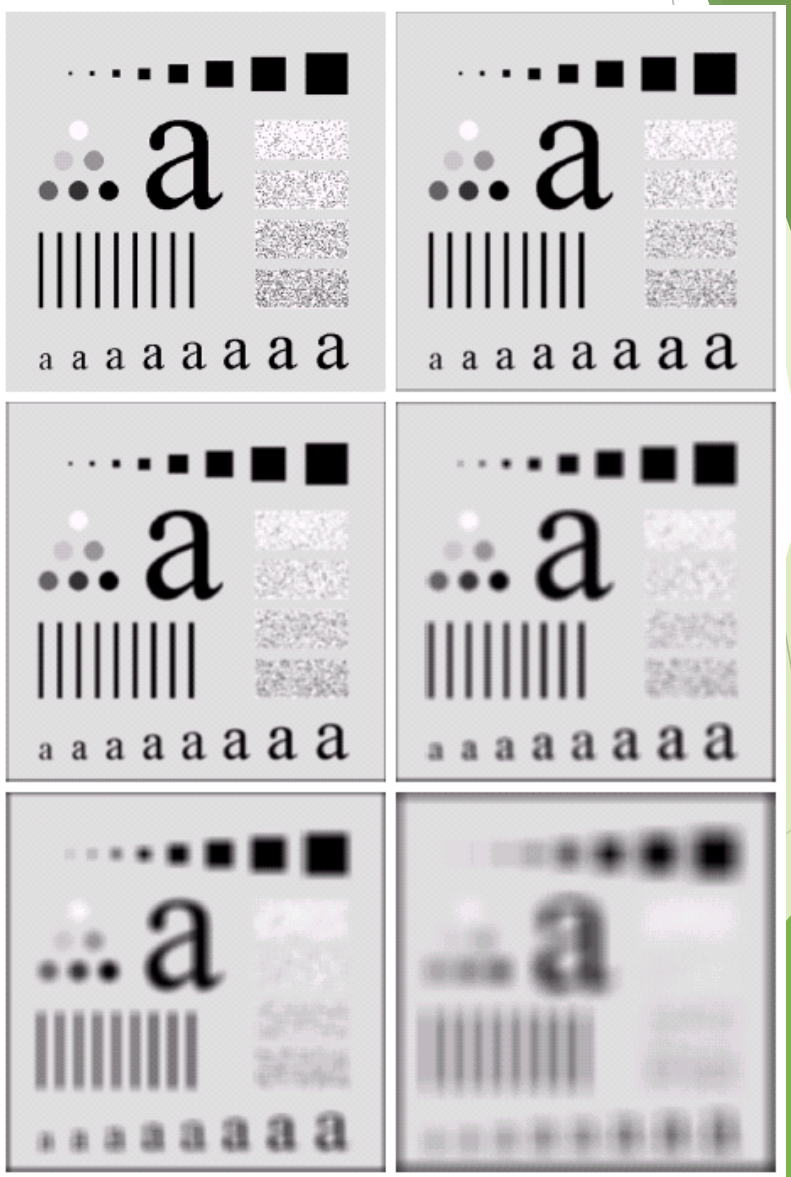
Image Smoothing Example

- The image at the top left is an original image of size 500*500 pixels

- The subsequent images show the image after filtering with an un-weighted averaging filter of increasing rectangular filter sizes
  - 3, 5, 9, 15 and 35

- Notice how detail begins to disappear with increase in neighbourhood size



Weighted Smoothing Filters

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- More effective smoothing filters can be generated by allowing different pixels in the neighbourhood different weights in the averaging function
  - Pixels closer to the central pixel are more important
  - Often referred to as a *weighted averaging*
  - Less blurring compared to un-weighted filter

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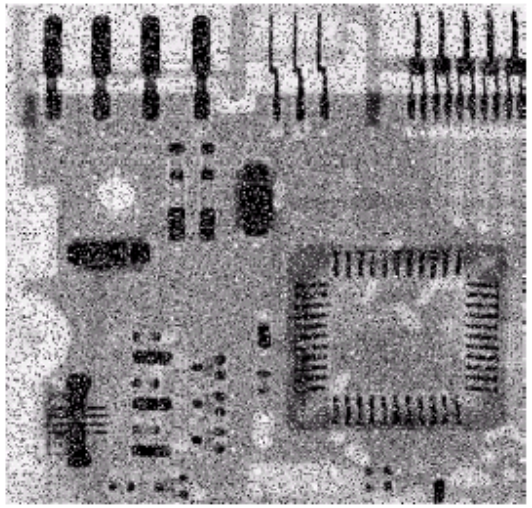
$^1/_{16}$	$^2/_{16}$	$^1/_{16}$
$^2/_{16}$	$^4/_{16}$	$^2/_{16}$
$^1/_{16}$	$^2/_{16}$	$^1/_{16}$

Weighted averaging filter

Averaging Filter Vs. Median Filter Example



Original Image With Noise

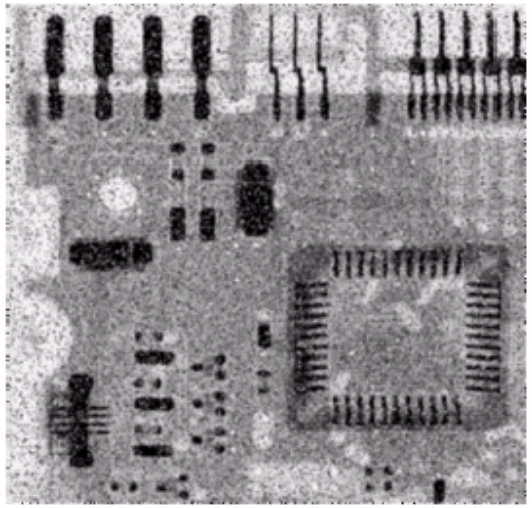


Image After Averaging Filter

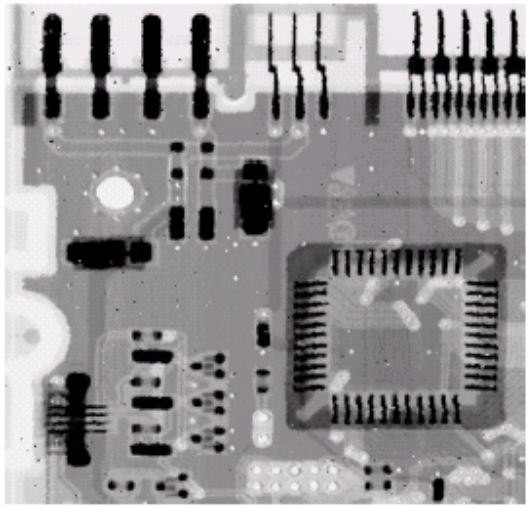


Image After Median Filter

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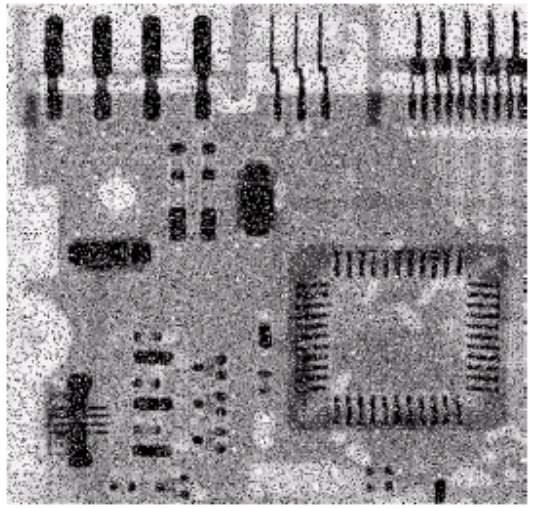
Averaging Filter Vs. Median Filter Example



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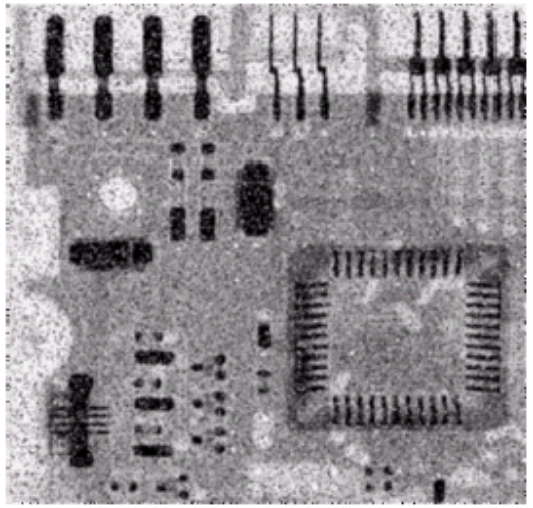

Image After Averaging Filter

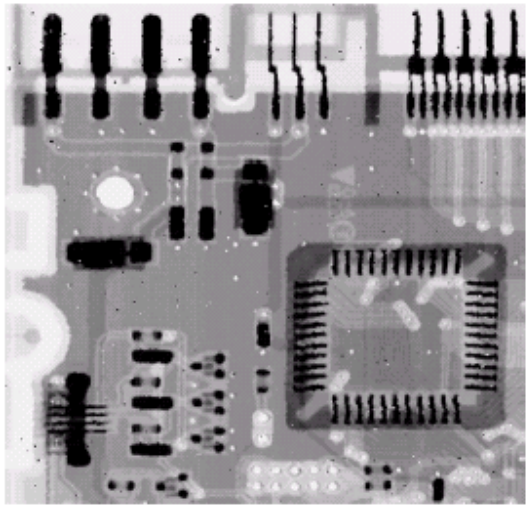

Image After Median Filter

- Filtering is often used to remove noise from images
- Sometimes a median filter works better than an averaging filter

Strange Things Happen At The Edges!

However strange things happen at the edges of an image since we are missing pixels to form a neighbourhood