



# Image Processing

## Intensity Transformation and Spatial Filtering (Part II)

Pattern Recognition and Image Processing Laboratory (Since 2012)



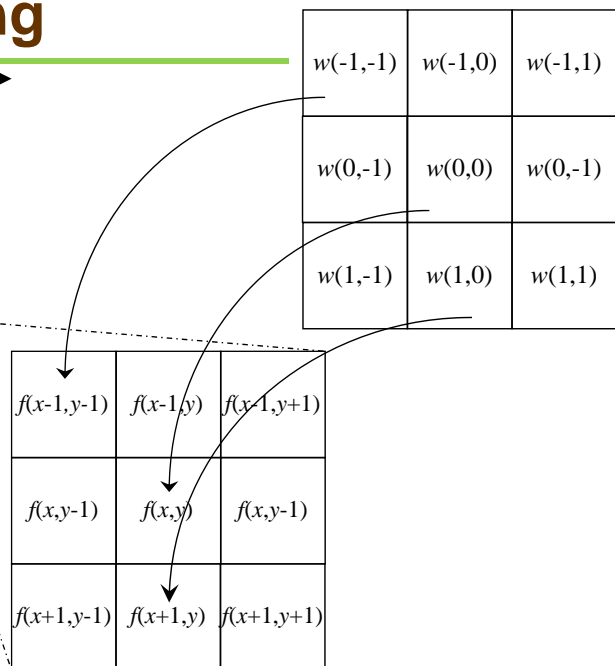
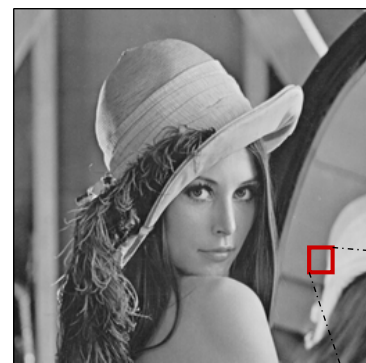
## Introduction

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### Spatial Domain Processing



## Spatial Filtering

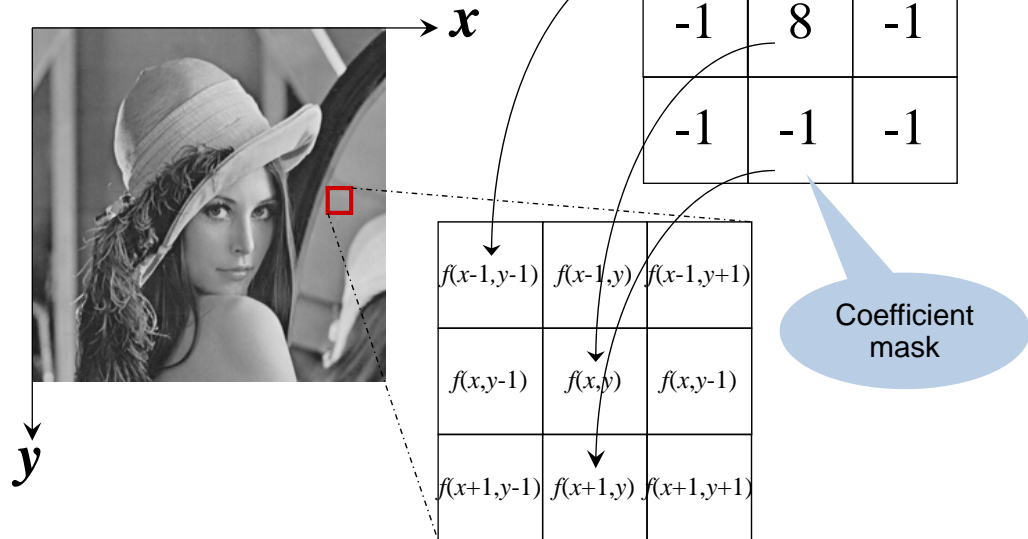


## Spatial Filtering



# Spatial Filtering

## Linear Spatial Filtering



# Spatial Filtering

## Linear Spatial Filtering

A 2-D linear spatial filter usually has the following properties:

- The **mask size** is symmetric, such as 3x3, 5x5, 7x7, ...
- The **operation** of a filter is based on convolution and correlation.



## Spatial Filtering

Linear Spatial Filtering: **Correlation**

$w(x,y)$

1	2	3			
4	5	6			
7	8	9			

$f(x,y)$

0	0	0	0	0	0
0	0	0	0	0	0
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Padded  $f(x,y)$



## Spatial Filtering

Linear Spatial Filtering: **Correlation**

1	2	3	0	0	0	0	0	0
4	5	6	0	0	0	0	0	0
7	8	9	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Initial operation

0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	9	8	7	0	0	0	0
0	0	6	5	4	0	0	0	0
0	0	3	2	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Correlation result



## Spatial Filtering

### Linear Spatial Filtering: Convolution

9	8	7	0	0	0	0	0	0	0
6	5	4	0	0	0	0	0	0	0
3	2	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Initial operation

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	1	2	3	0	0	0	0
0	0	0	4	5	6	0	0	0	0
0	0	0	7	8	9	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Convolution result



## Spatial Filtering

The following syntax is used when implementing IPT standard linear spatial filters.

$g = \text{imfilter}(f, w, \text{'filter mode'}, \text{'boundary option'}, \text{'size options'})$

Filter mask

Input image



## Spatial Filtering

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**>> ex3\_04 % See demonstration**



## Spatial Filtering

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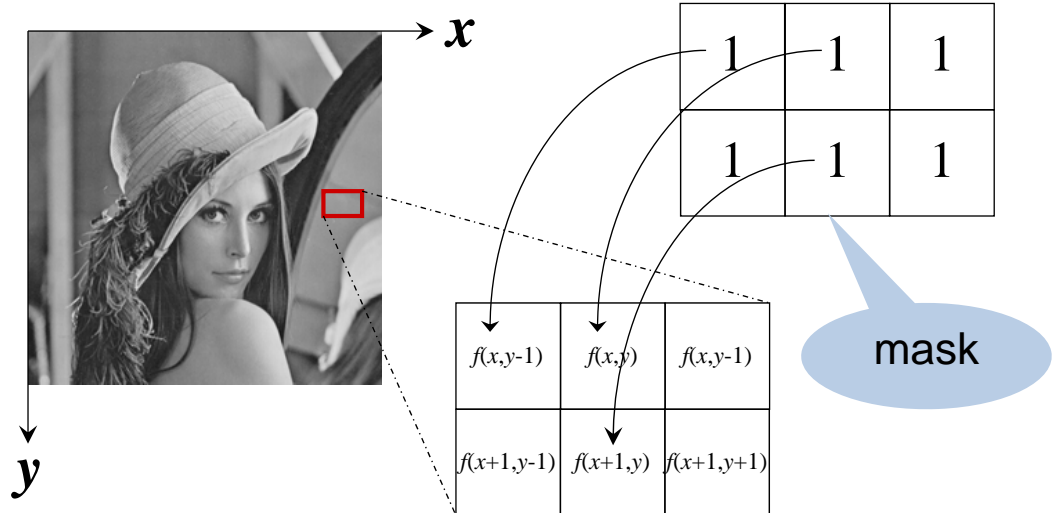
### Non-linear Spatial Filtering

A 2-D non-linear spatial filter usually has the following properties:

- The **mask size** can be both symmetric and asymmetric forms, such as 2x2, 2x3, 3x3, 3x4, 5x7, ...
- The **operation** is directly performed on image pixels.

## Spatial Filtering

### Non-linear Spatial Filtering



## Spatial Filtering

The following syntax is used for implementing generalized non-linear spatial filters.

mask

`g = colfilt(f, [ m n ], 'sliding', @function, parameter)`

Input image



## Applications of Non-linear Spatial Filtering: Image Enhancement

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**>> ex3\_04 % See demonstration**



## Applications of Non-linear Spatial Filtering: Noise Filtering

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**>> ex3\_04 % See demonstration**





The end of  
part II