

Using Images in Scientific studies

An introduction into digital image analysis

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Introduction



Leonardo Da Vinci, 1508

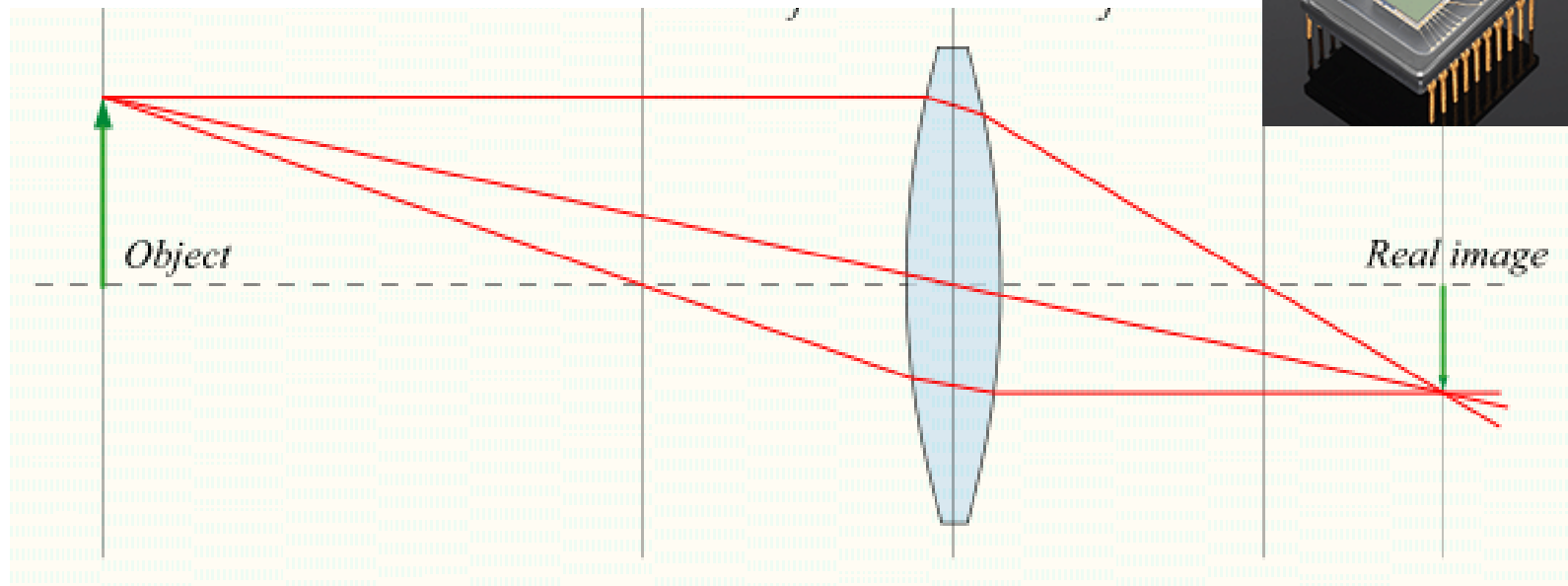
Introduction

- Visual documentation of our physical world
 - Drawings
 - Projections
 - Pictures
- Desire to:
 - Measure
 - Compare
 - Condense information
- "The digital era"
 - Pictures
 - Processing and analysing techniques

Objective and Content

- Give a short introduction into digital image analyses
 - What is a digital image?
 - Processing vs. Analysis
 - Image segmentation
 - An application as example

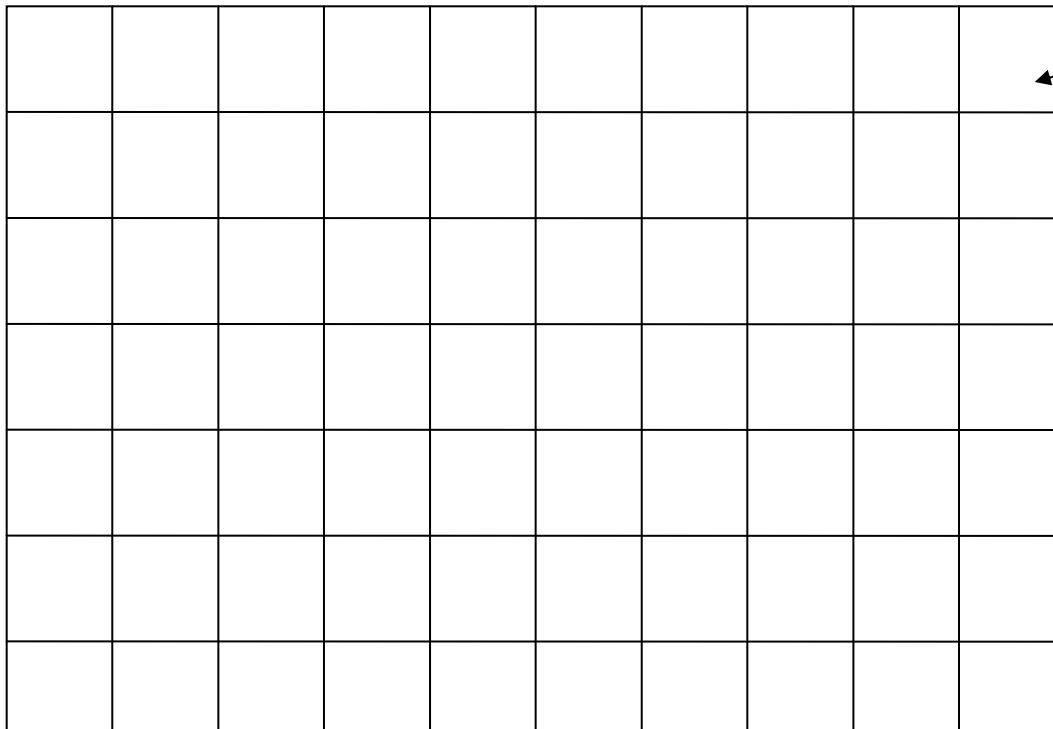
What is a digital image?



2D Image plane

What is a digital image?

- Image plane



Picture element
(pixel)

What is a digital image?

Every pixel has a certain color



What is a digital image?

How to describe a color mathematically?

Pixel color



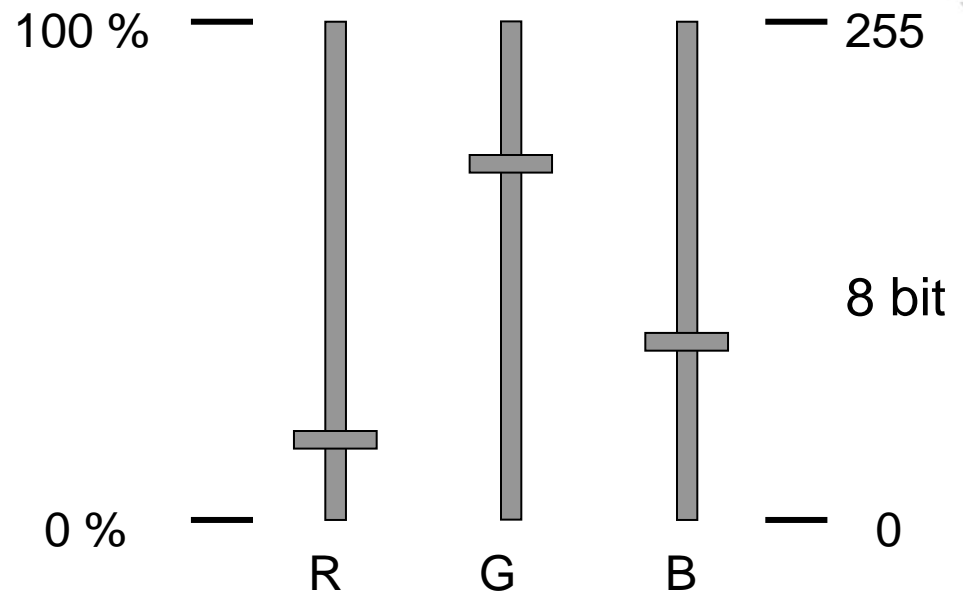
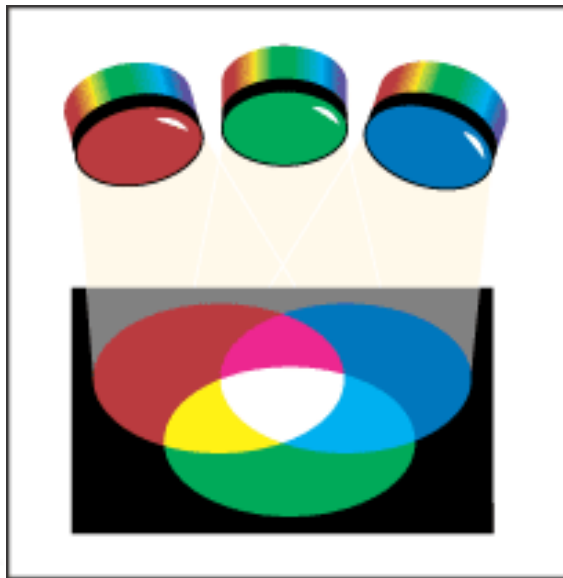
Color space Coordinate system (Color Space)

- RGB (Red Green Blue)
- Hue-Saturation-Brightness
- CMYK
- L^*a^*b
-

What is a digital image?

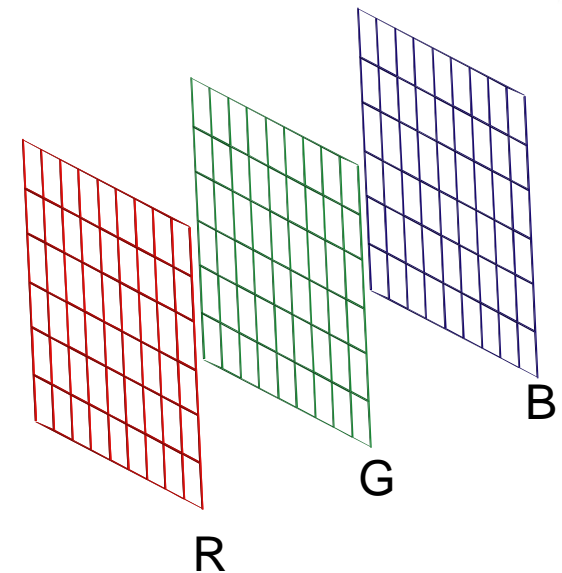
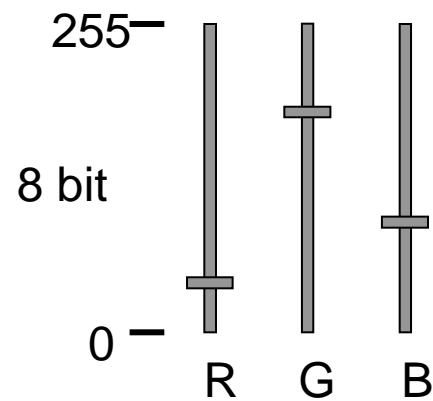
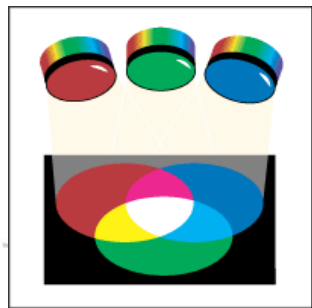
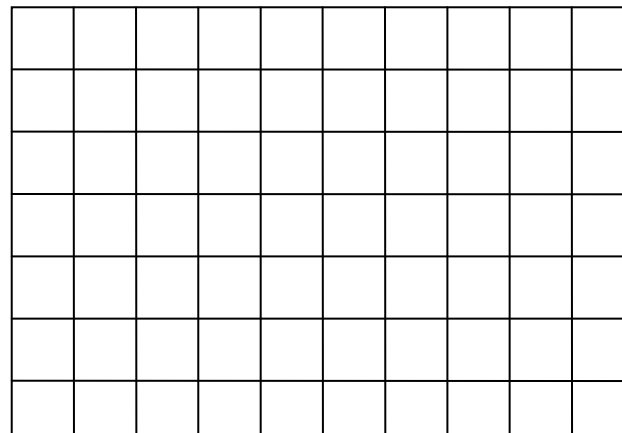
RGB model

- Tre channels: Red, Green, Blue
- Based on the human visual system
- CCD/CMOS sensors measure light in RGB

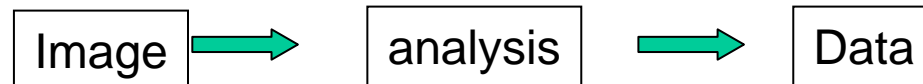
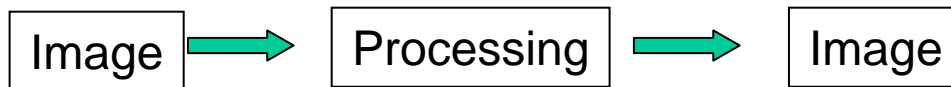


What is a digital image?

Image plane



Processing vs. analysis



Most demanding

Only image processing

Correction for lighting conditions

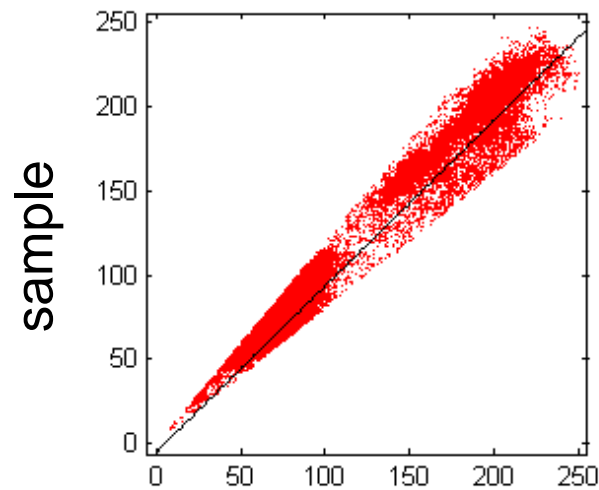


standard

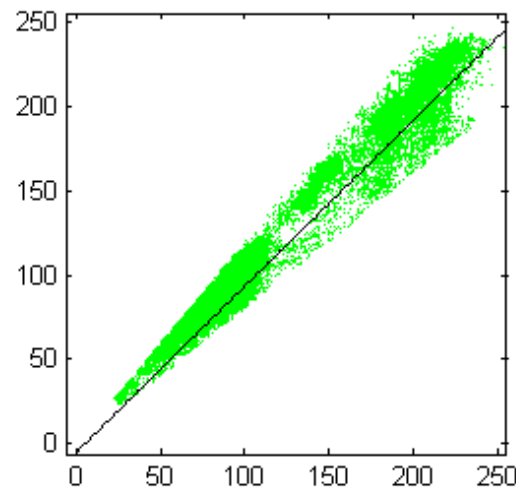


sample

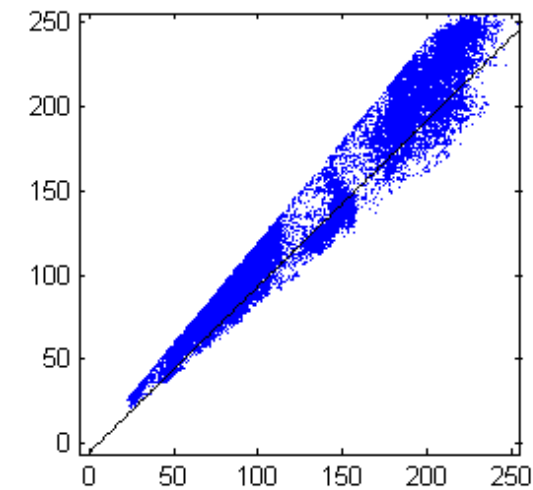
Only image processing



standard



standard

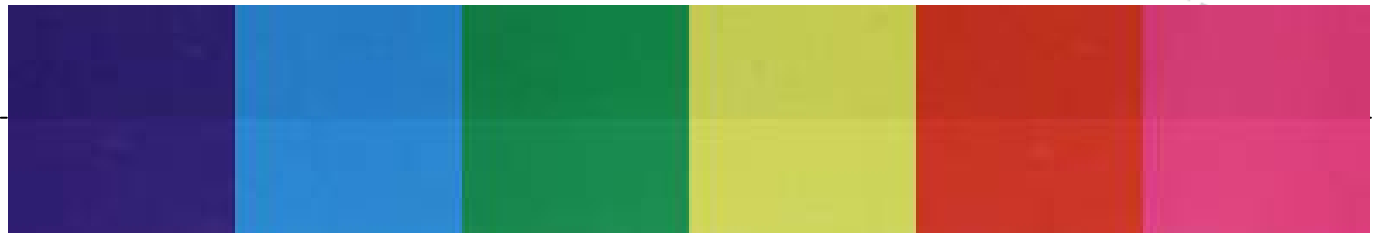


standard

Only image processing

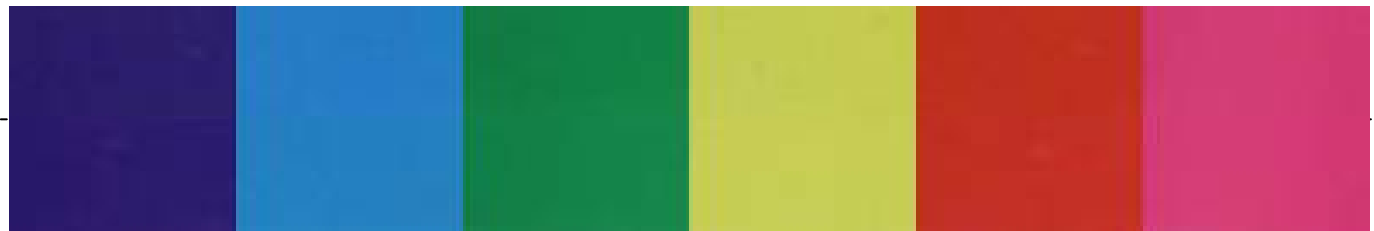
Before correction

standard
sample



After correction

standard
sample



Only image processing

Correction for lighting conditions



Simple, pixel based processing
Image as output

Image processing

- Processing before analysis:
 - Obtain a workable image
 - Reduction of information

image processing

- Reduction of information
 - Grey scale

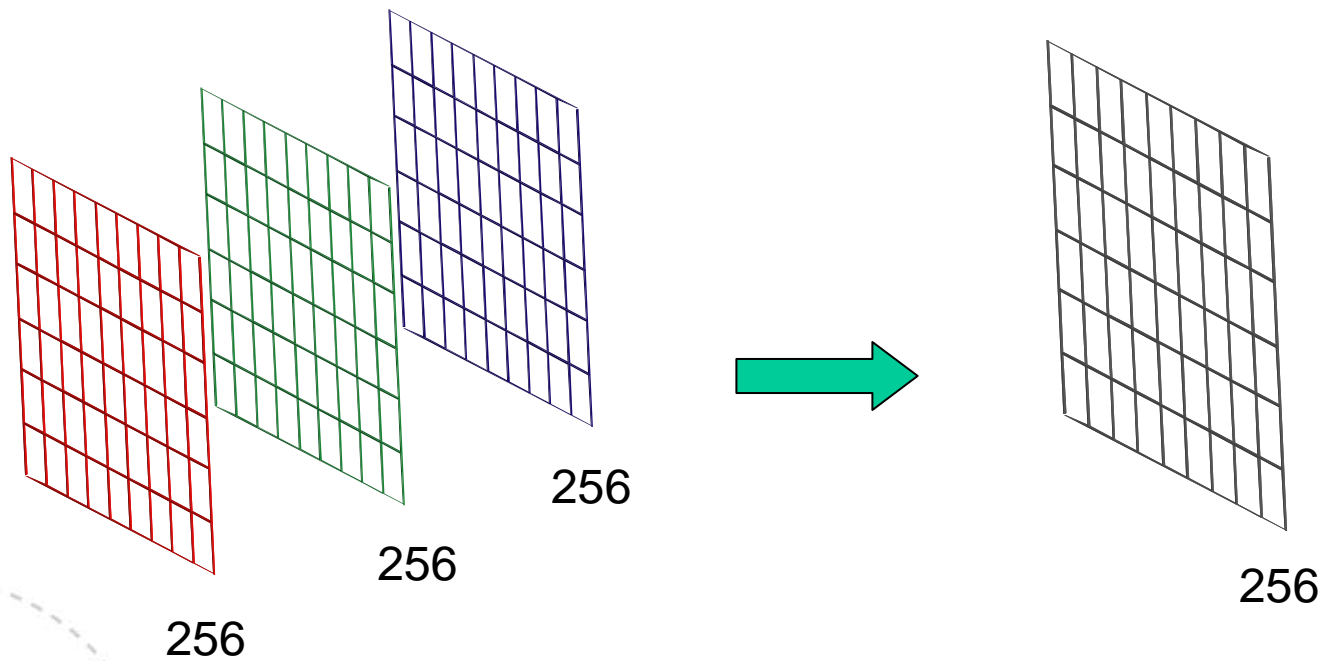


Image processing



```
A=imread('pingvin.jpg');
```

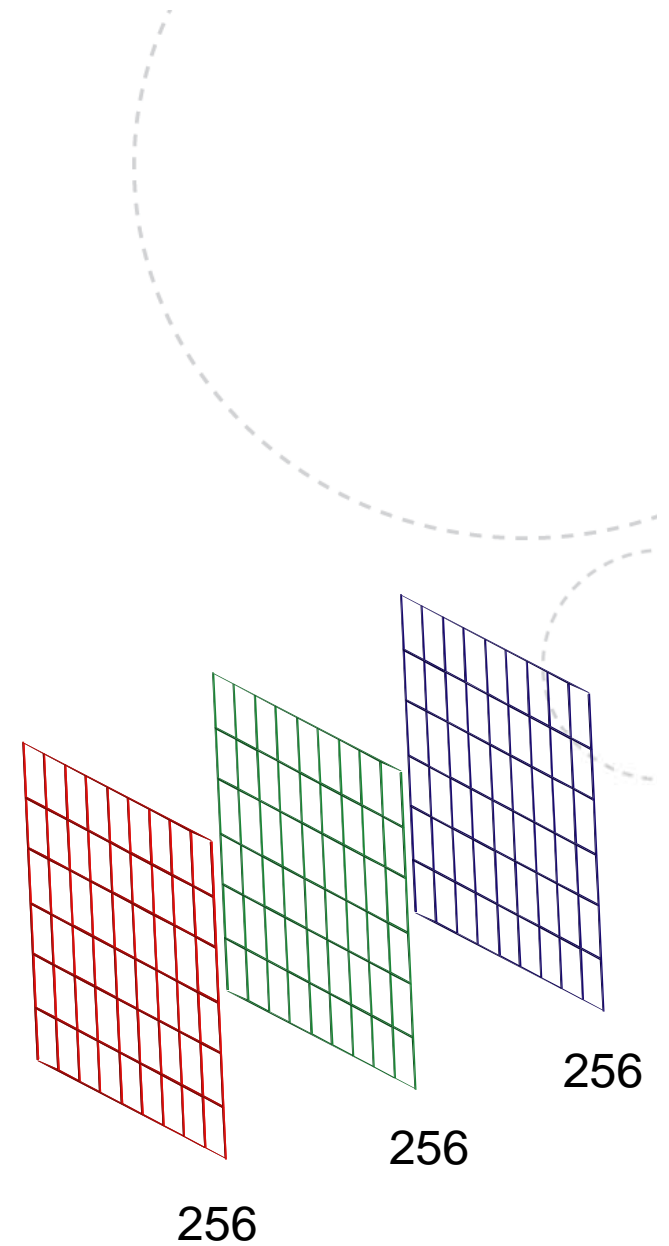
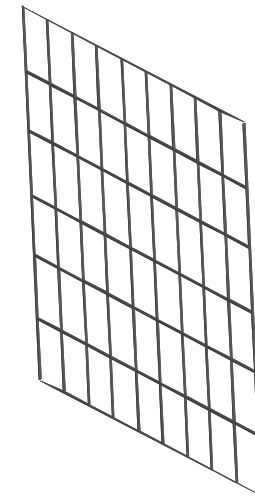


Image processing



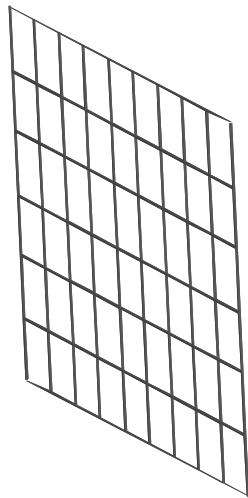
$$B = \text{mean}(A, 3)$$



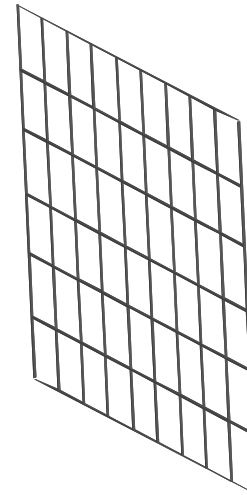
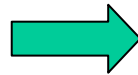
256

Image processing

- Reduction of information
 - Gray scale
 - Quantification

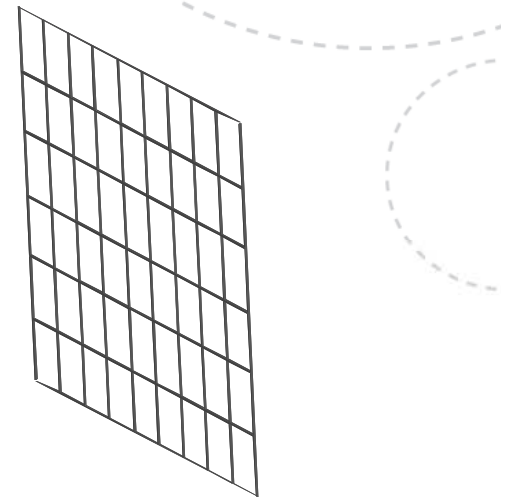


256 levels



3 levels

Image processing



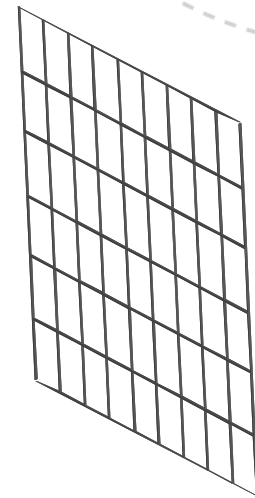
256

Image processing



$$C = \text{round}((B./255). * 3)$$

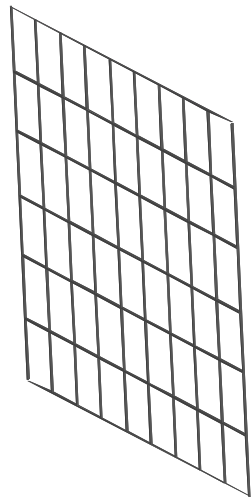
$$C = C.*255/3$$



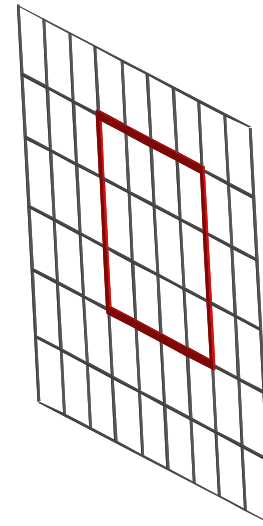
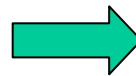
3

Image processing

- Reduction of information
 - Gray scale
 - Quantification
 - Region of interest

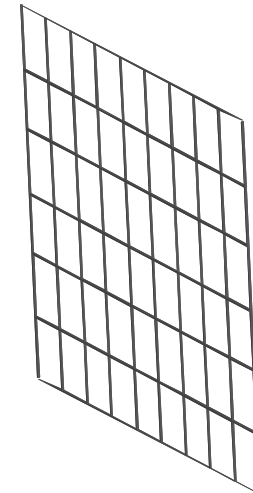


3 levels



3 levels

Image processing



3

Image processing

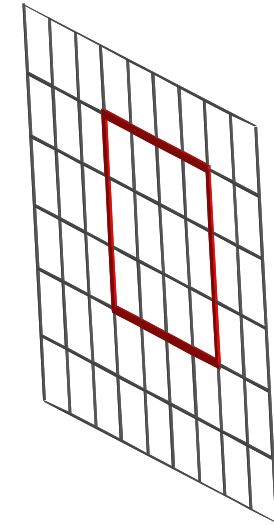

$$D=C(250:700,150:670)$$


Image segmentation

- From pixel to object

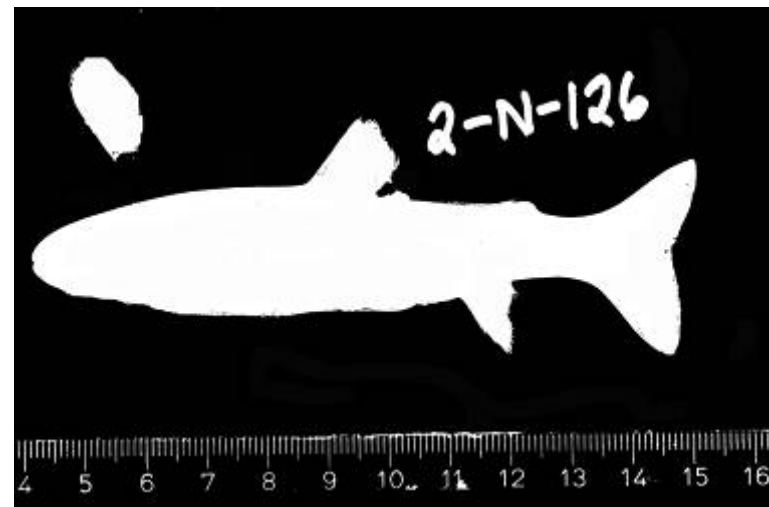
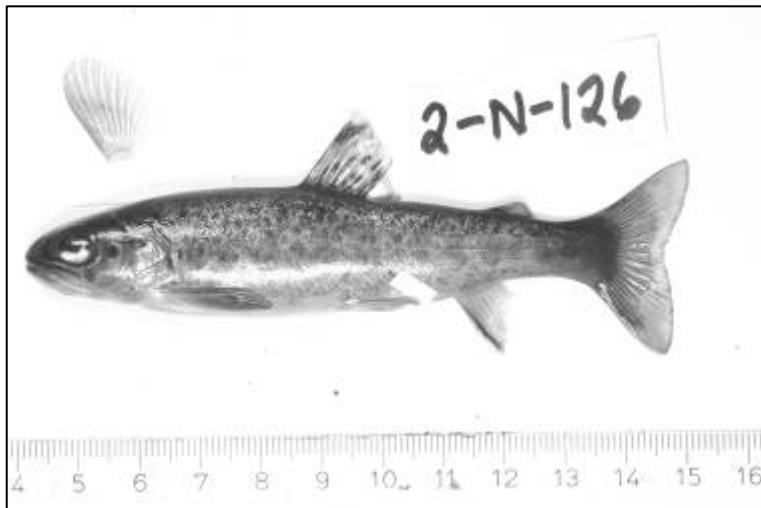
An object is an interconnected group of pixels with a physical meaning

Objects have properties:

- Length
- Width
- Shape
- Area
- Position
- Color

Image segmentation

An example



White : Pixels that belong to an object

Black : Pixels that do not belong to an object

Image segmentation

- You need processing tools (algorithms)
 - Quantification
 - Simple mathematical operators (add, subtract, multiply, divide,.....)
 - Color information
 - Threshold criteria
 - Convolution (smoothing)



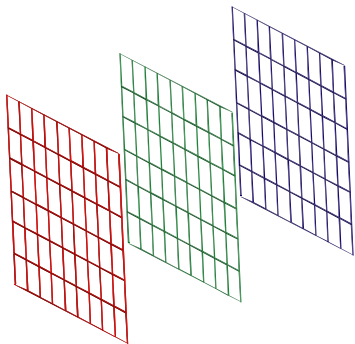
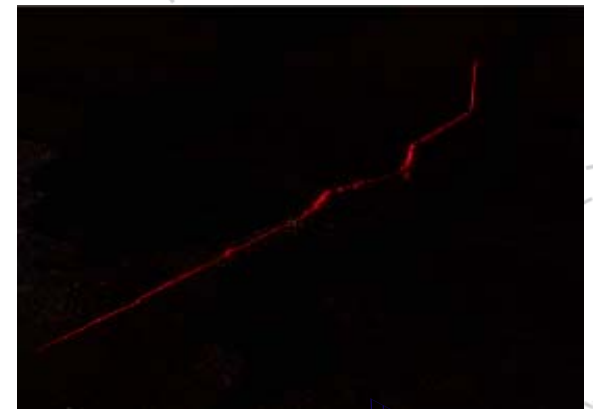
Image segmentation



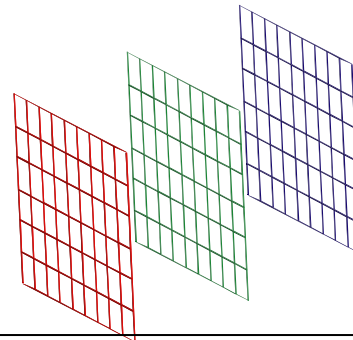
-



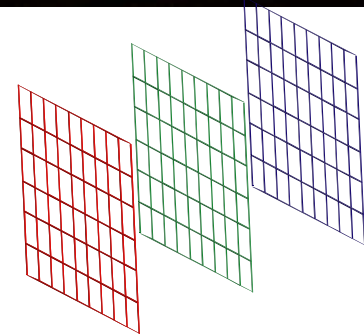
=



-



=



```
A = imread('bilde1.jpg');  
B = imread('bilde2.jpg');  
  
C = abs(A-B);
```

Image segmentation

- You need processing tools (algorithms)
 - Quantification
 - Simple mathematical operators (add, subtract, multiply, divide,.....)
 - Color information
 - Threshold criteria
 - Convolution (smoothing)



Image segmentation

- The problem of “loose pixels”

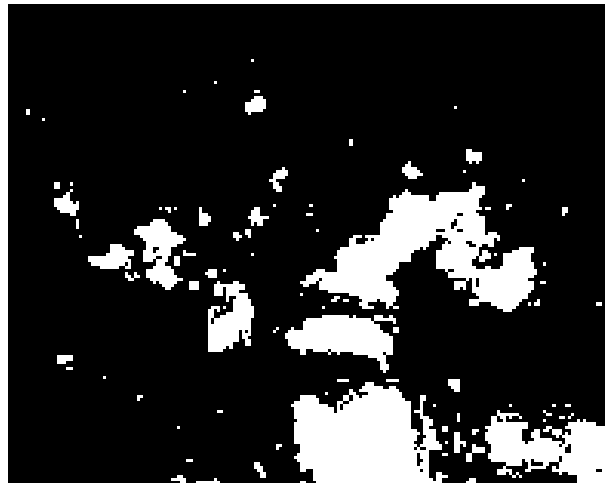


Image segmentation

Image

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

Operation

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

Result

| | | | | | |
|--|-----|--|--|--|--|
| | | | | | |
| | 2/9 | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Mask

| | | |
|-----|-----|-----|
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |

$$0 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 1 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 1 \cdot 1/9 = 2/9$$

Image segmentation

Image

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

Operation

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

Result

| | | | | | |
|--|-----|-----|--|--|--|
| | | | | | |
| | 2/9 | 3/9 | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

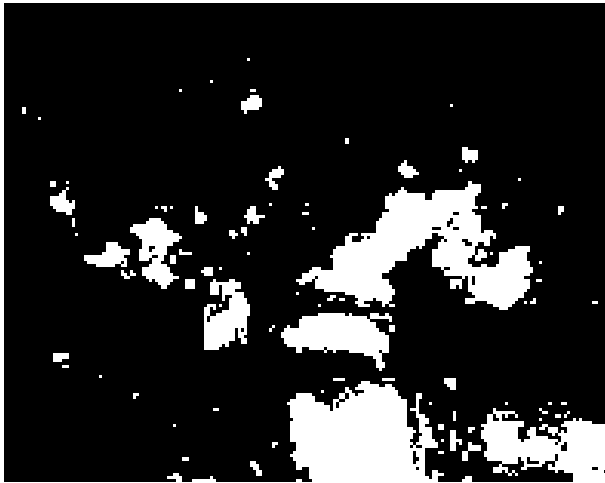
Mask

| | | |
|-----|-----|-----|
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |

$$0 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 1 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 0 \cdot 1/9 + 1 \cdot 1/9 + 1 \cdot 1/9 = 3/9$$

Image segmentation

Before



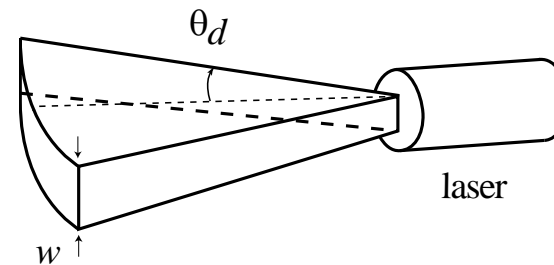
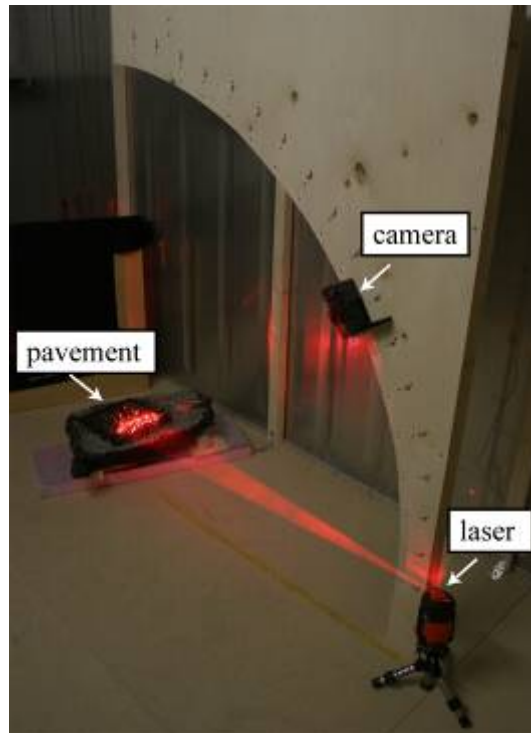
After



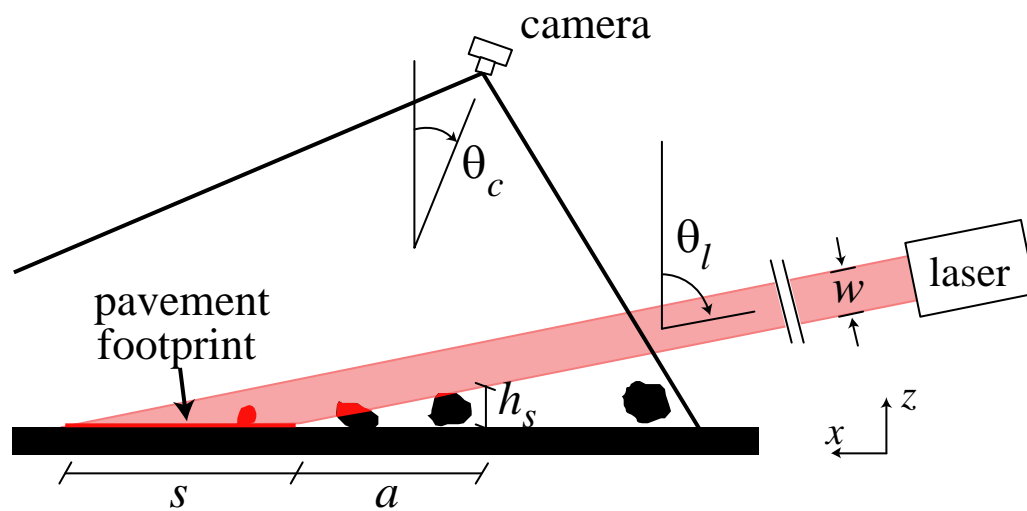
Image is ready for analyses

An example

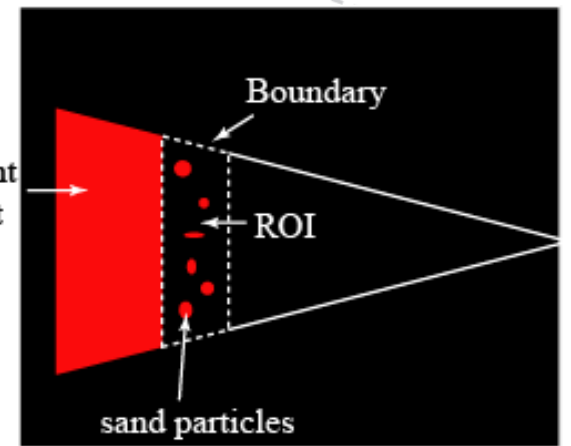
- The detection of sand particles on an iced pavement



An example

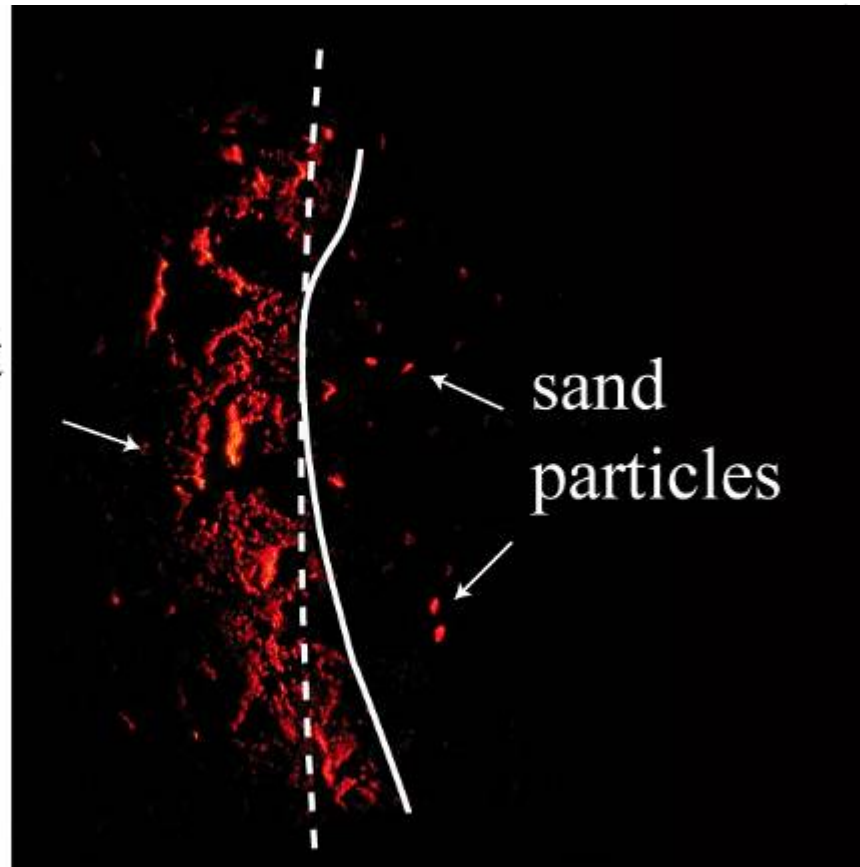


pavement
footprint



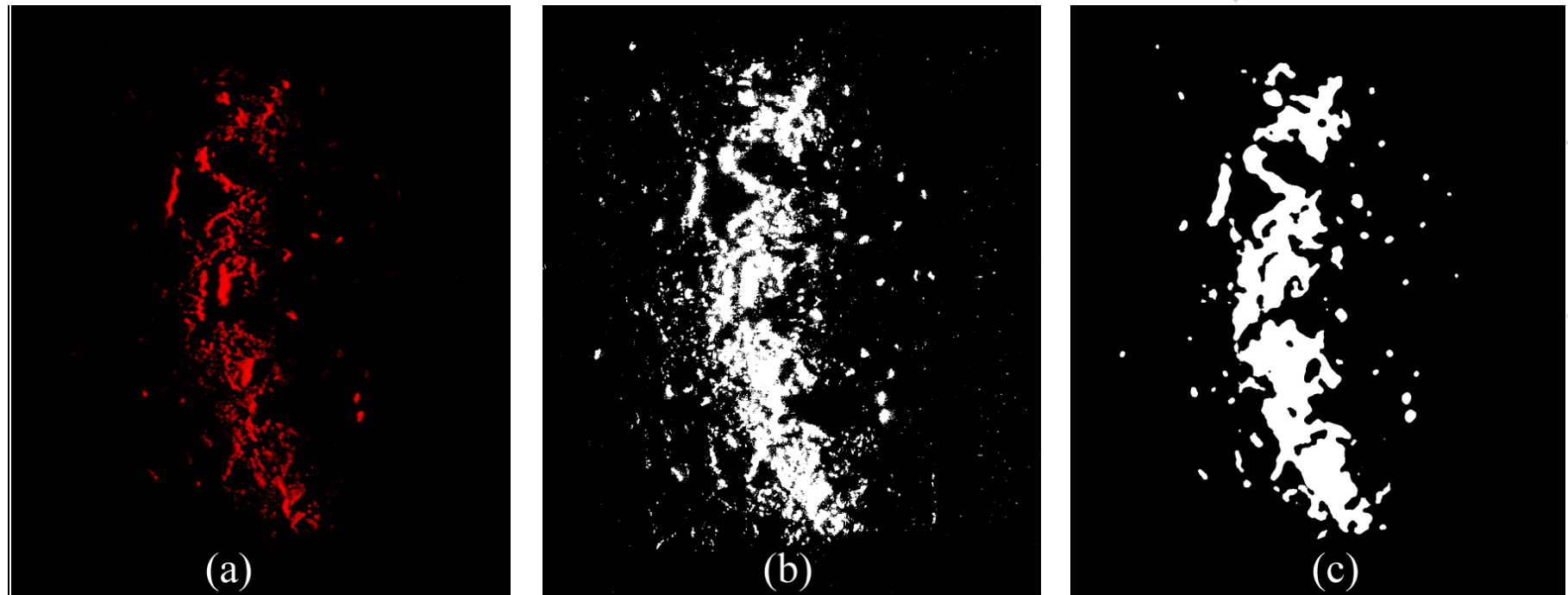
An example

pavement
footprint



sand
particles

An example



Original image

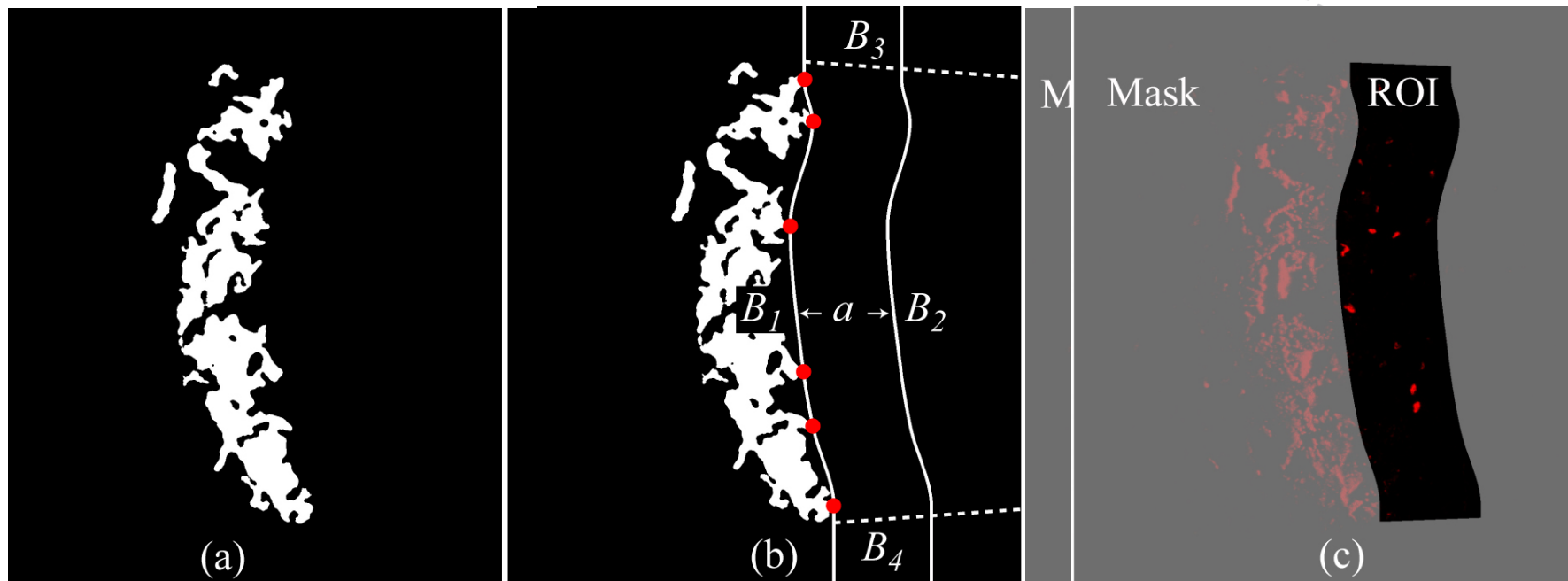
Information reduction

Segmentation

→
Only red channel
threshold

→
Convolution

An example



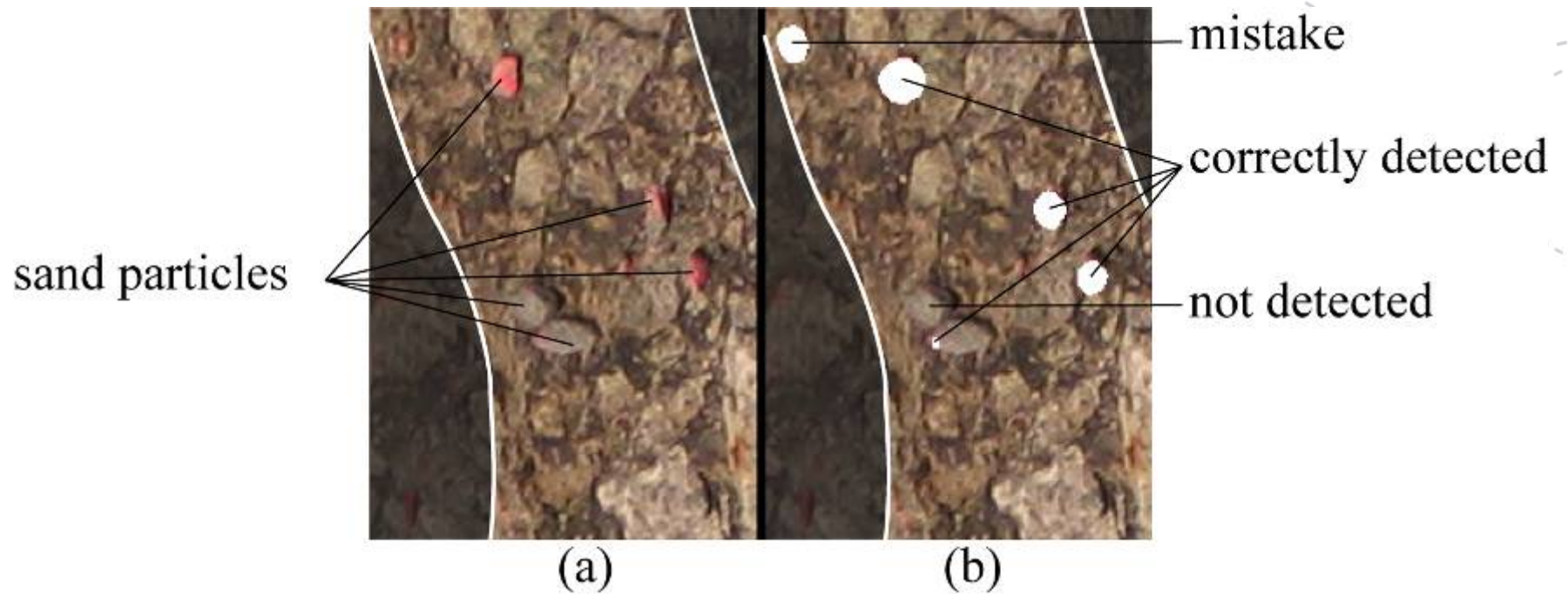
Removal of small objects
(< 4 mm)

Finding the boundaries

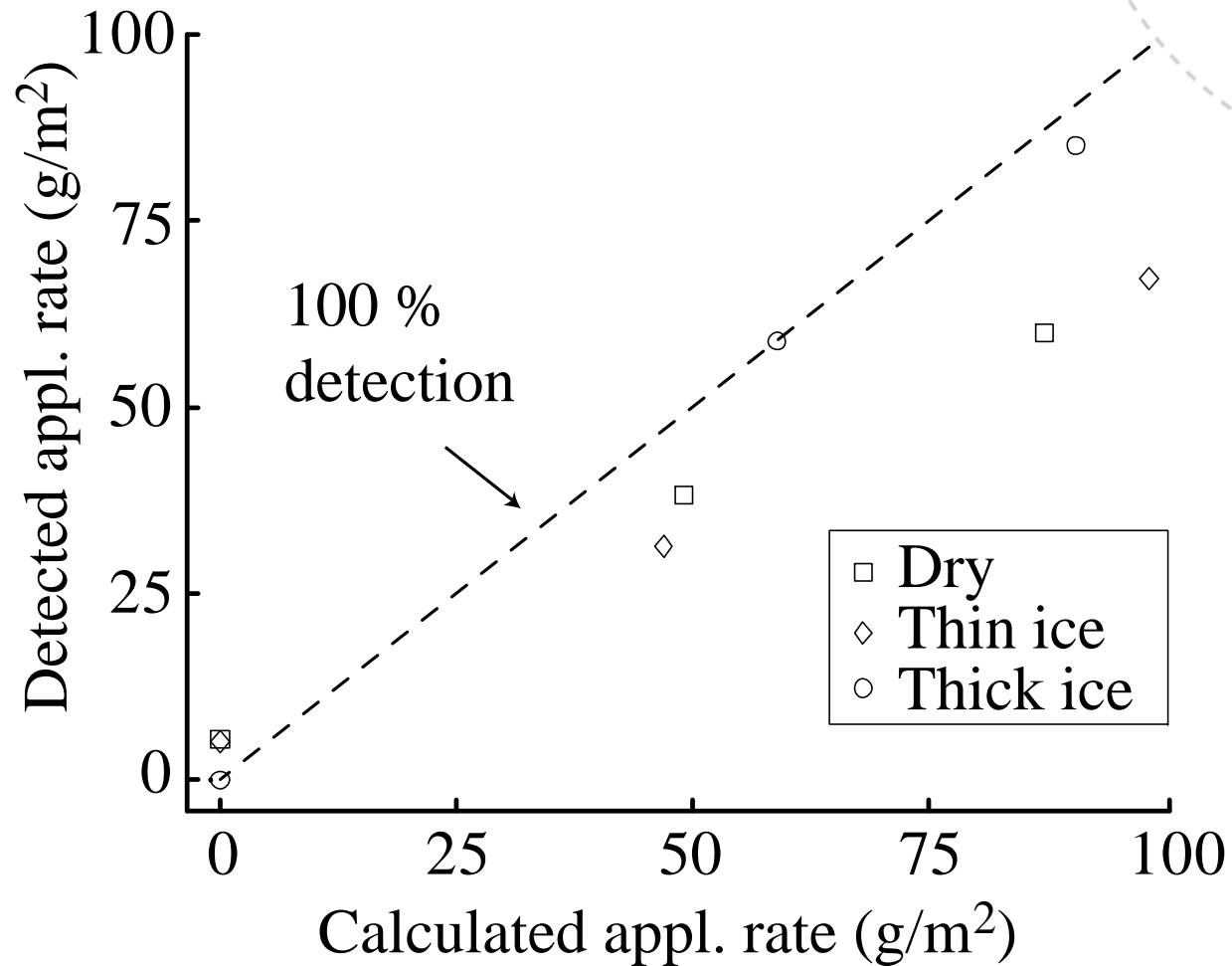
Define the ROI

Find objects within the ROI

An example



An example



Thank you for your attention