Lesson:
Digital image pre-processing: Part 1

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IDEA MAP SUDAN

African Population and Health Research Center

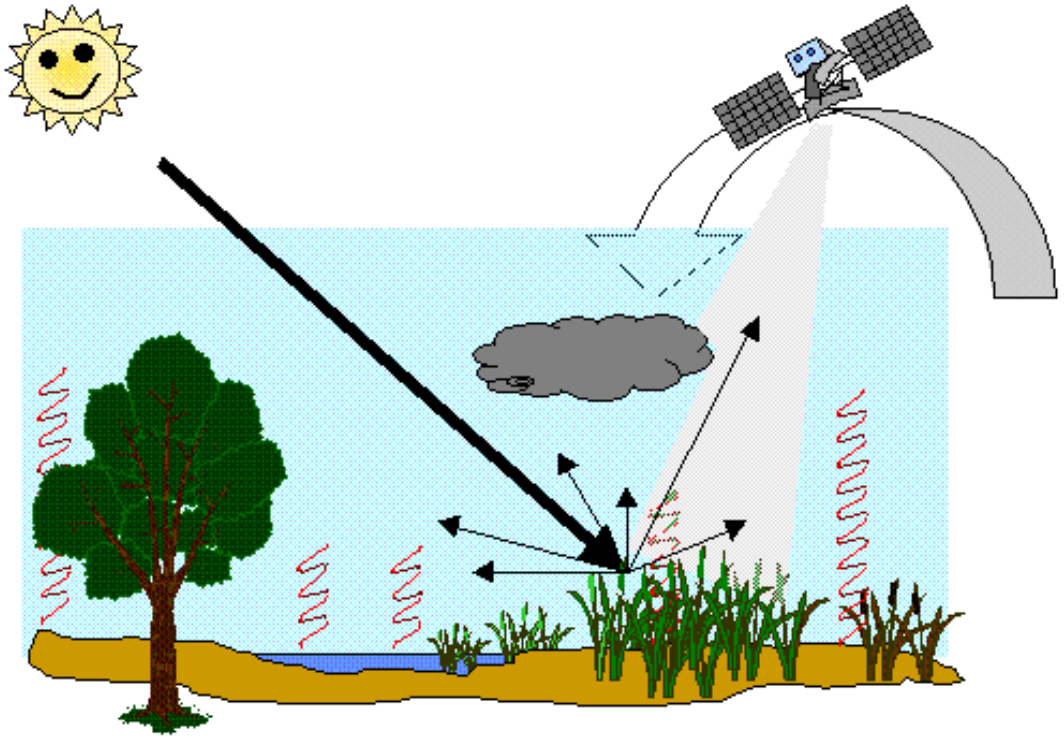
ITC UNIVERSITY OF TWENTE.

ULB

Nuffic meet the world

Optical main physical quantity:

REFLECTANCE

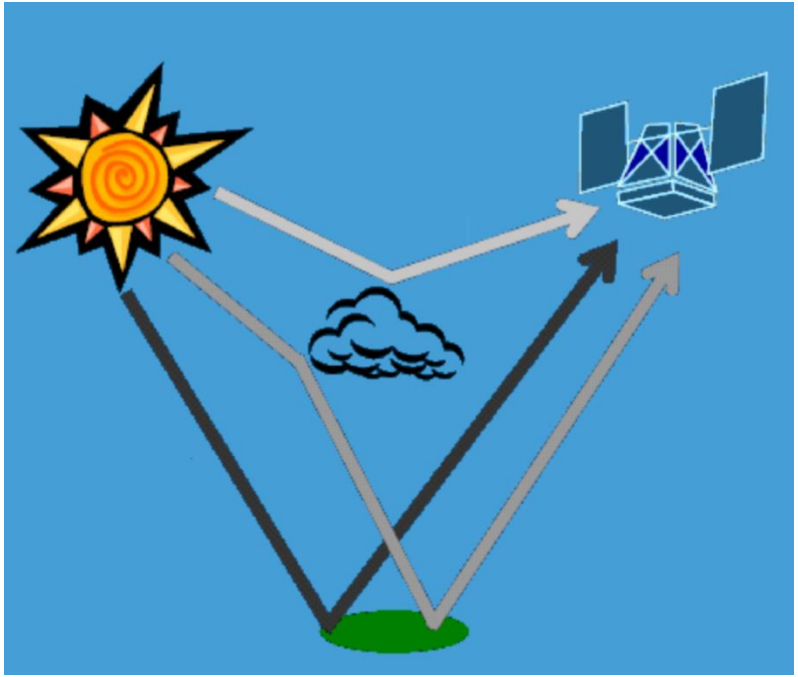


Source of variation in the observed quantity

Sun power

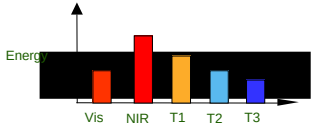
Sensor degradation

Sun position (illumination geometry) (distance)



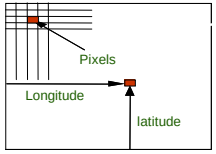
Satellite position (observation geometry)

Sensor characteristics



Wavelength

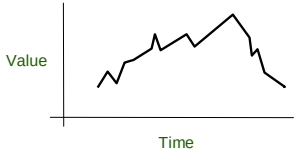
Atmosphere composition



Spatial distribution

Target properties **P**

Topography



Temporal variation

…

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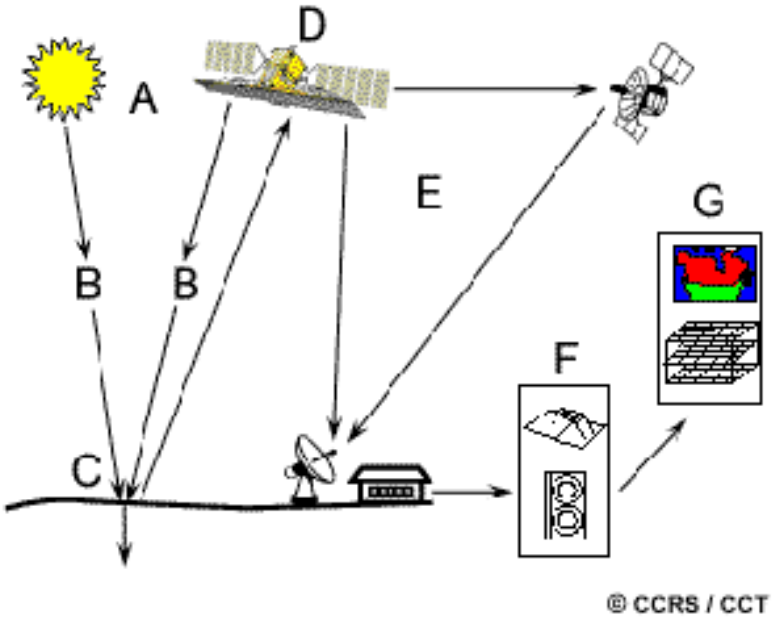
Image pre-processing

The operations and corrections that are carried out to improve an image before processing and analysis

Image pre-processing

Corrections (usually) required before image processing and analysis

- Geometric correction
- Radiometric calibration & correction
  - Sensor imperfections
  - Sun elevation correction
  - Atmospheric correction
- Image enhancement



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Pre-processing corrections should be adapted to the needs

Different needs = different uses

1. Image enhancement

What is image enhancement?

Improves the visual appearance of digital images for visual interpretation

- Sensors & platforms designed to deal with many situations -> image not optimised for visual interpretation
- No ‘standard’ enhancement
- Enhance image for application required

!! Any radiometric and geometric pre-processing should be carried out first

Image enhancement techniques

- 2 main techniques:

  Histogram operations e.g. contrast stretching, histogram equalisation

  Spatial filter operations e.g. smoothing, sharpening, edge enhancement

- Also a type of enhancement: image fusion e.g. pan-sharpening

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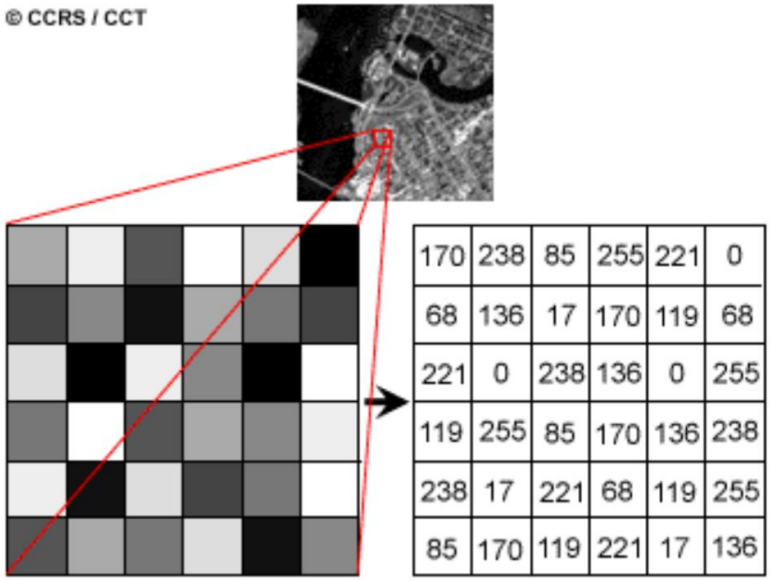
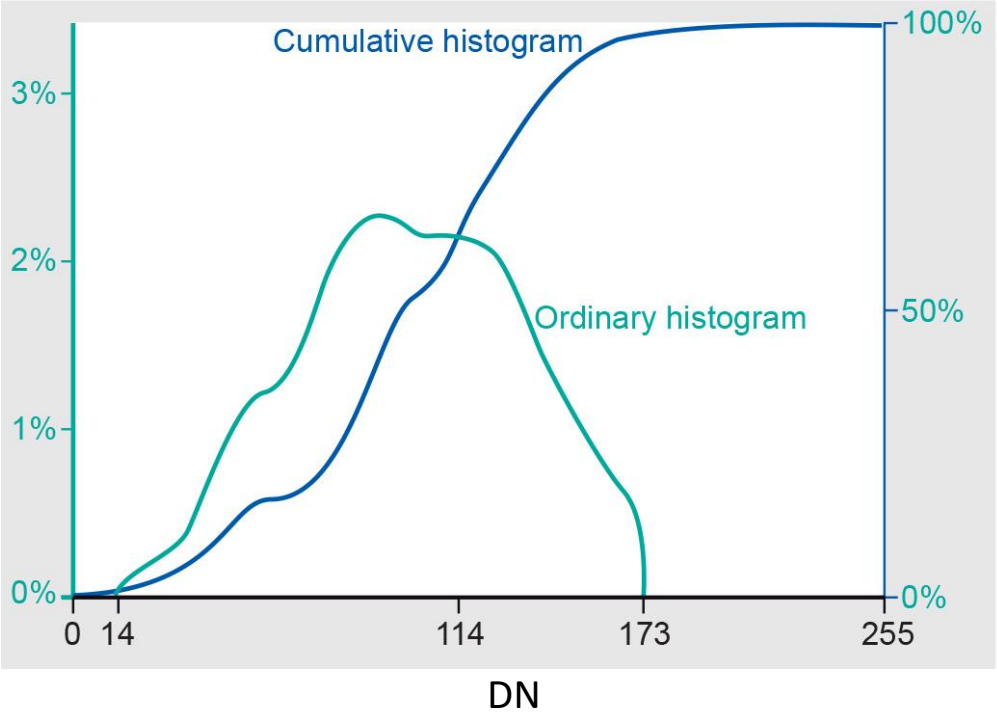
1.1 Histogram operations

Image histograms





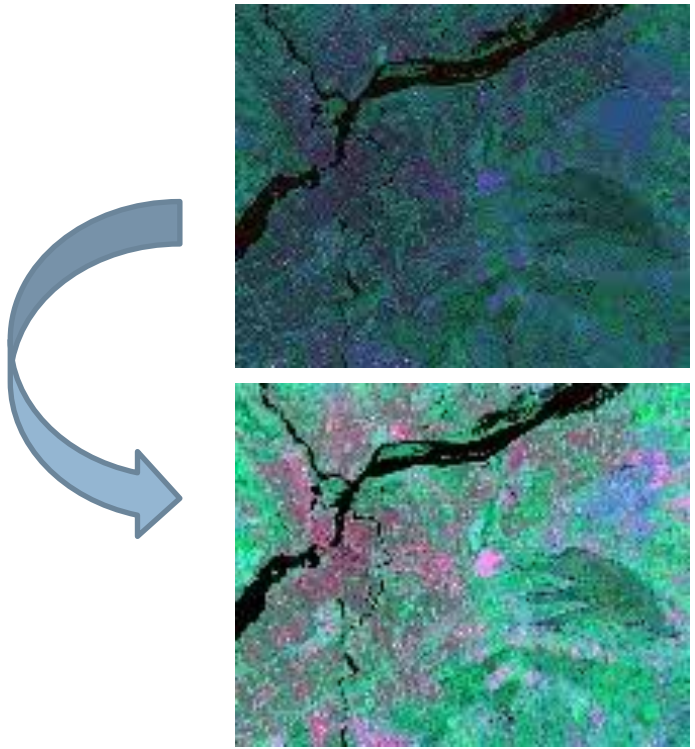
- 8-bit: 0 – 255
- 16-bit: 0 - 65535

https://ltb.itc.utwente.nl/481/concept/78837

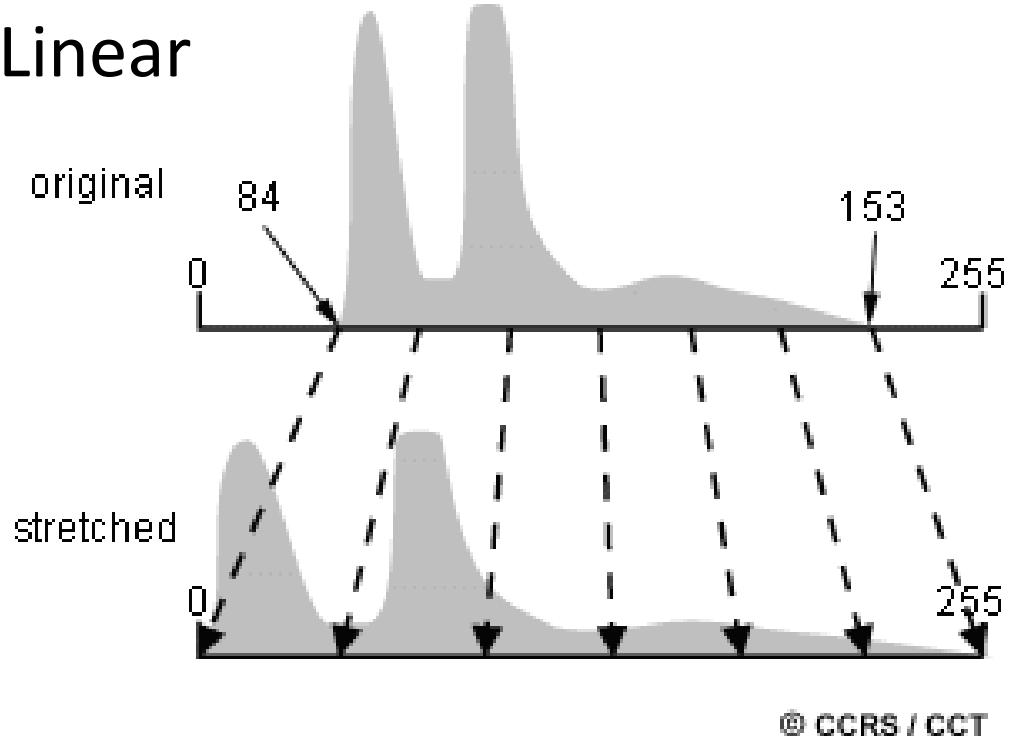
Histogram operations

- Use the image histogram to increase ***visual*** distinction between features
- Look at pixel values, without considering where they occur => ***Global contrast enhancement***
- Assign new values based on a look-up table => does not modify original data !
- E.g. Linear contrast stretch & histogram equalisation

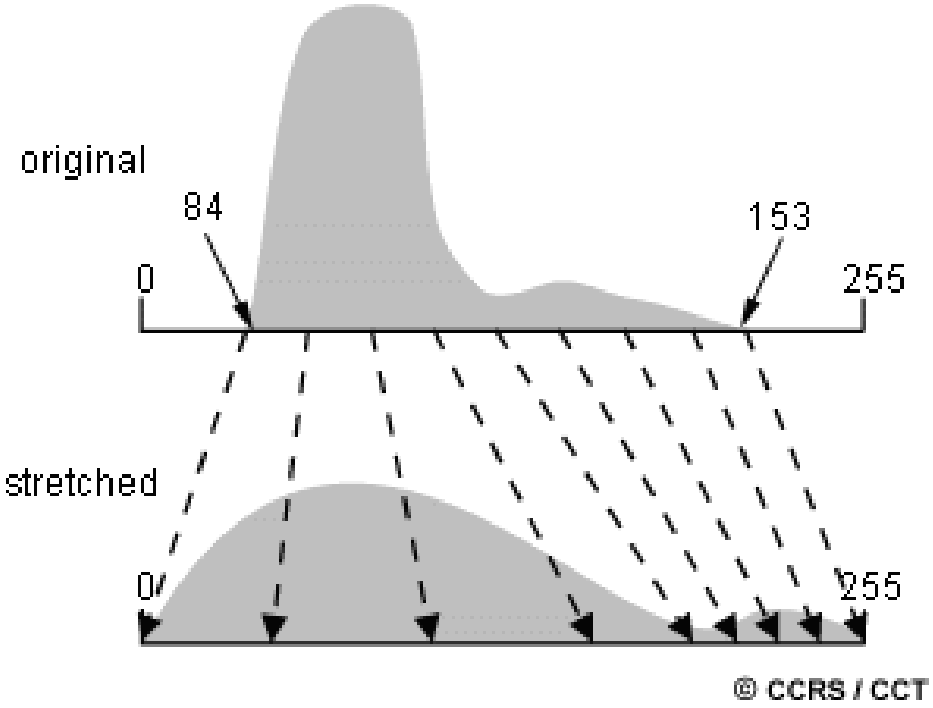
Linear contrast stretch



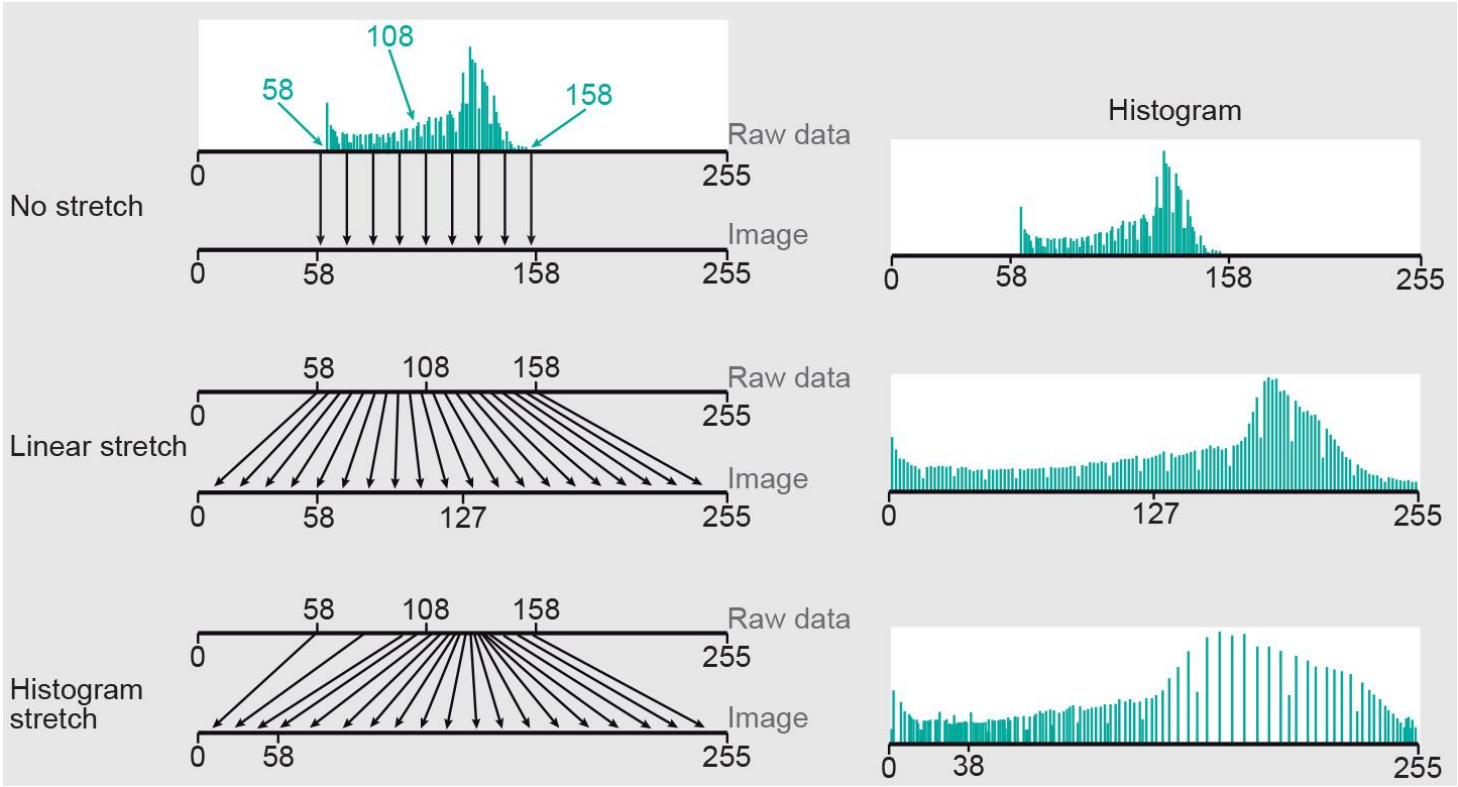
- Linear



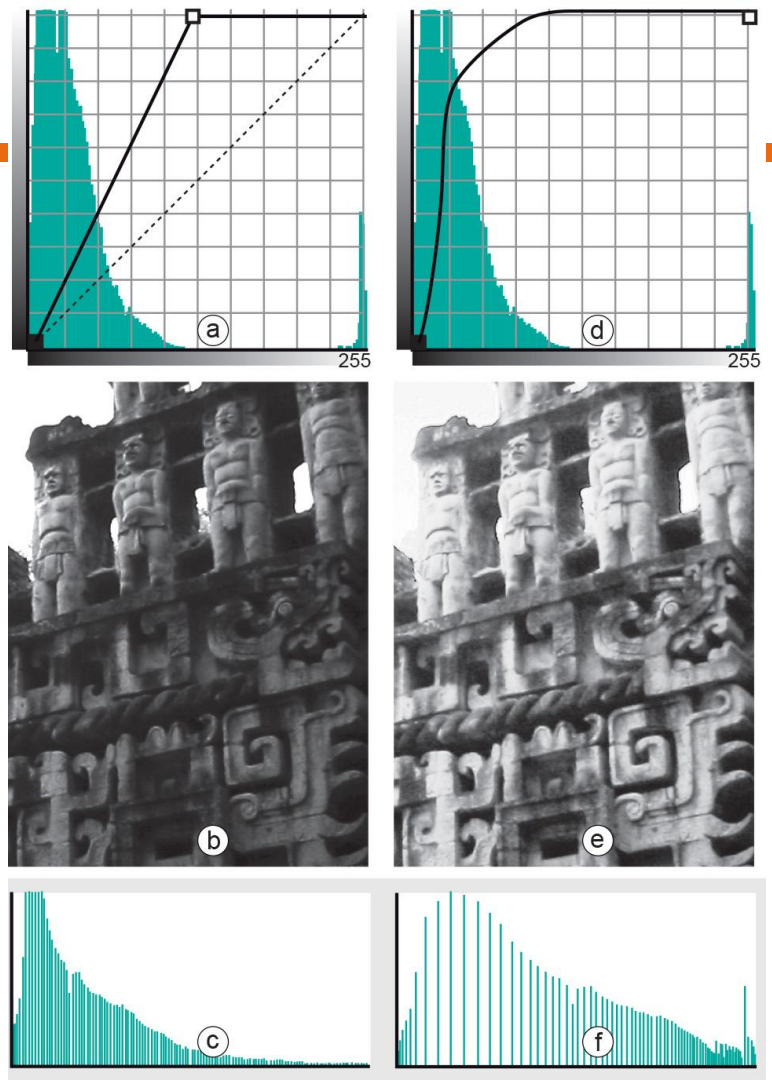
Histogram equalisation



- Non-linear

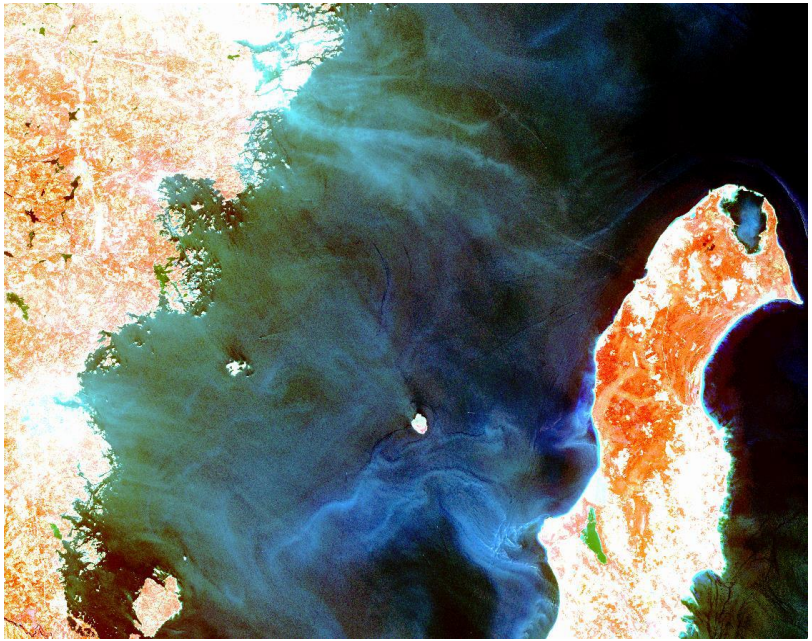


https://ltb.itc.utwente.nl/481/concept/78667

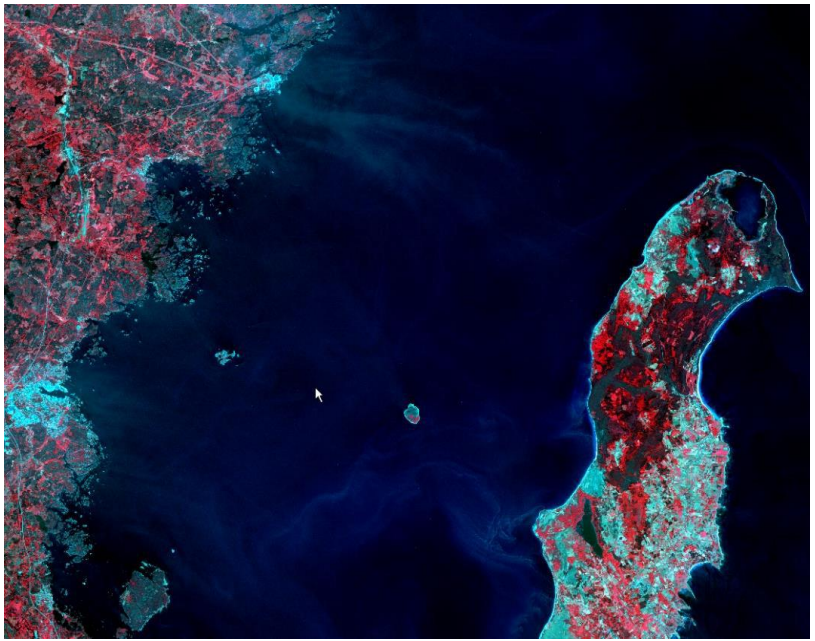


Adapted from
https://ltb.itc.utwente.nl/481/concept/78667

Custom histogram stretches



Stretched to enhance water pixels



Stretched to enhance land pixels

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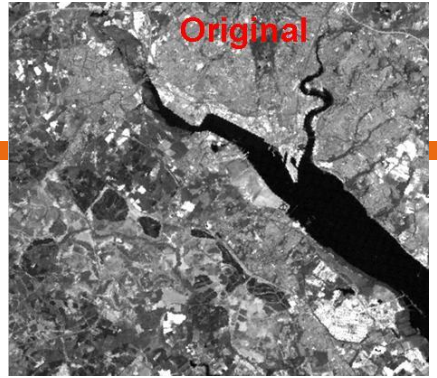
1.2 Spatial filter operations

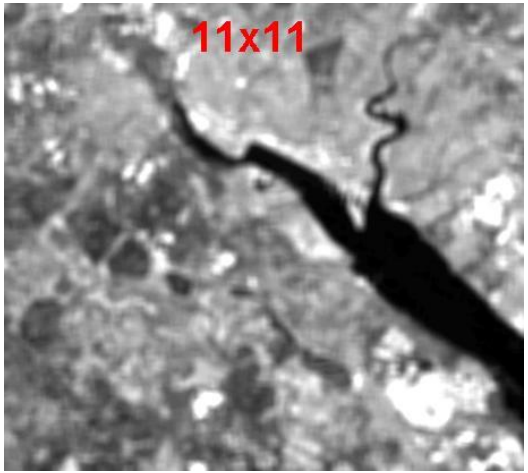
Spatial filter operations

- Usually for a single band
- Look at pixel values spatially in relation to their neighbours => ***Local contrast enhancement***
- Modifies original data !
- E.g.
  - Low pass filters (smoothing)
  - High pass filters (sharpening)
  - Directional filters (edge detection)

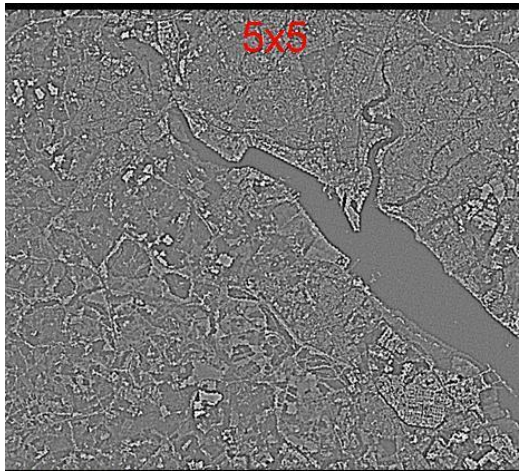
Example filter operations



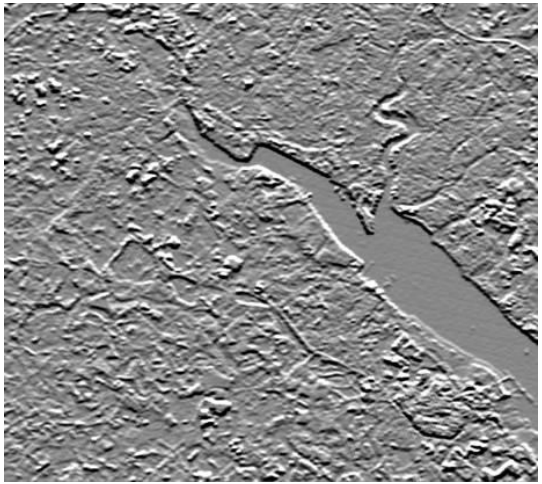
Low pass filters
Smoothing



High pass filters
Sharpening



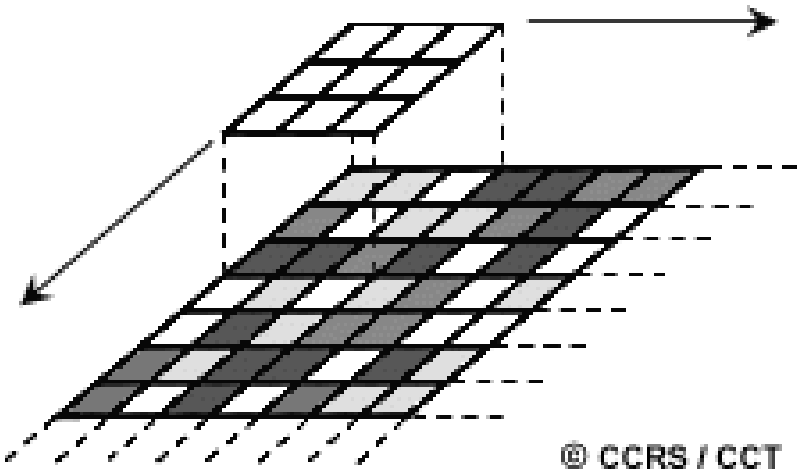
Directional filters



https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/high_pass_filters.html

https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/low_pass_filters.html

Filtering window - kernel

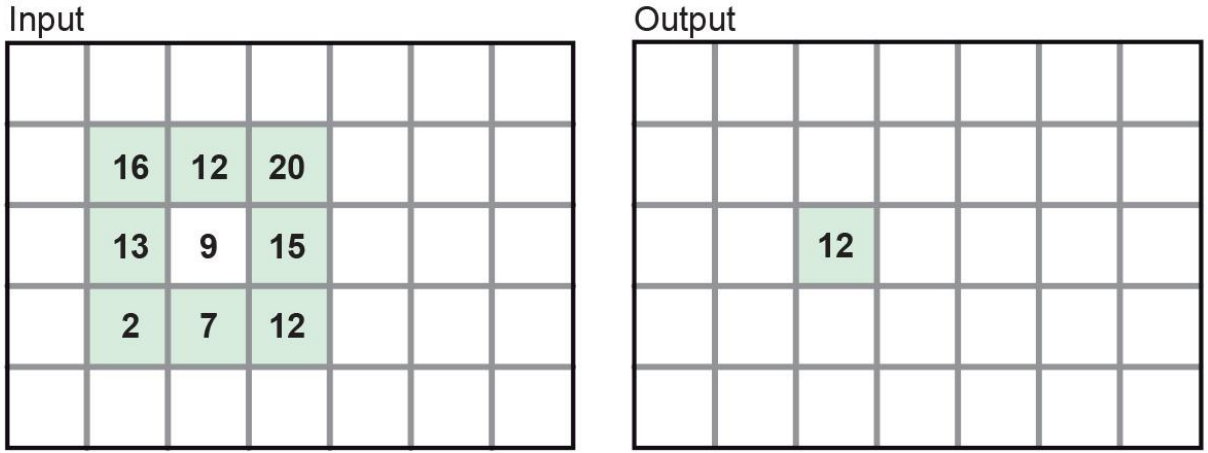


- Smooth data (low pass), enhance detail (high pass), highlight linear features (directional)
- Neighbourhood operations – central cell given new value as a function of its neighbours
- Windows usually square – 3x3 or 5x5…
- Increased filter effect with increased window size

Low pass filters - Smoothing

Example 1 – average:

https://ltb.itc.utwente.nl/481/concept/78628



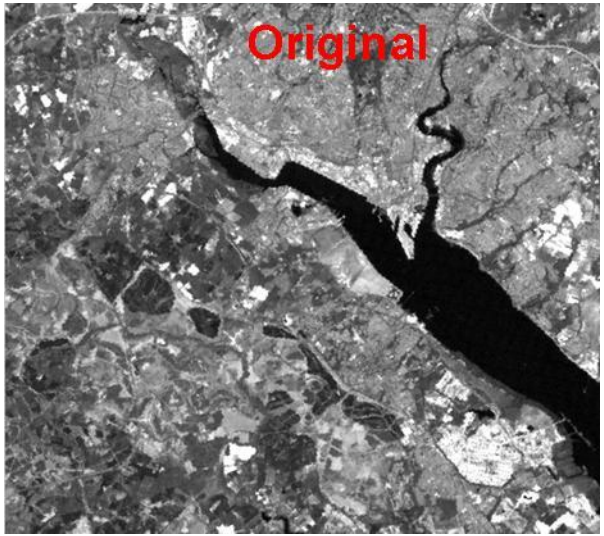
3x3 kernel (i.e. weight matrix)

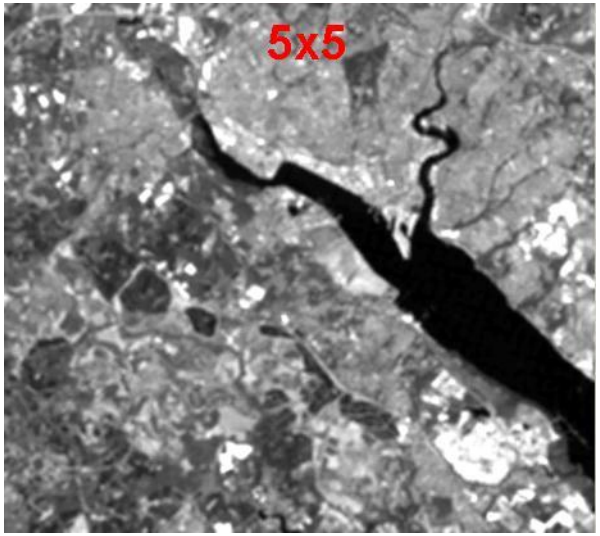
1	1	1
1	1	1
1	1	1

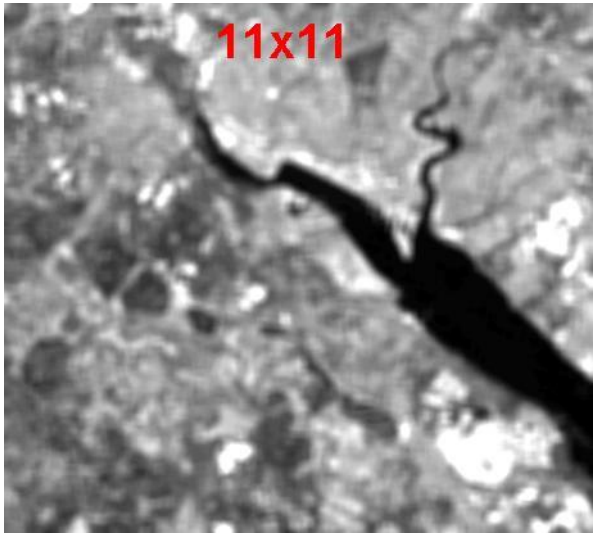
$$\frac{16 + 12 + 20 + 13 + 9 + 15 + 2 + 7 + 12}{9} = 12$$

= Moving average filter

Image smoothing example



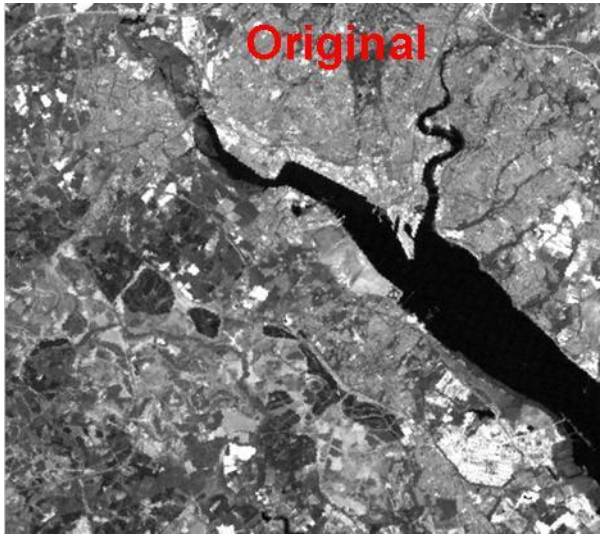


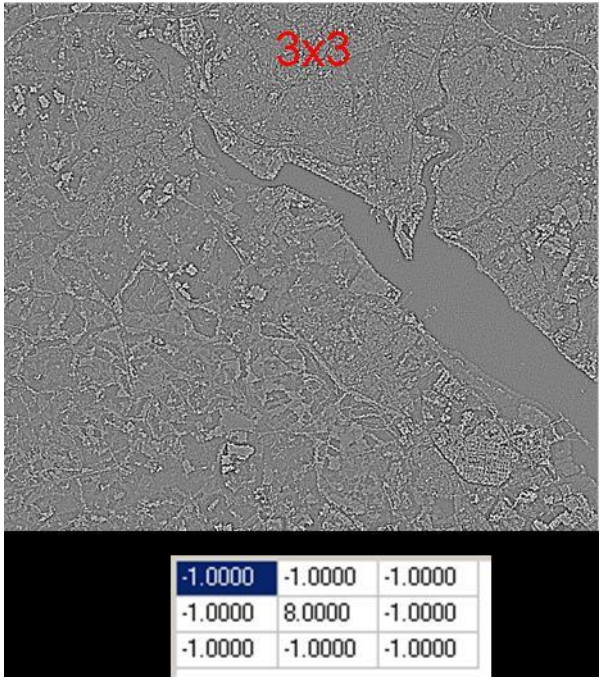


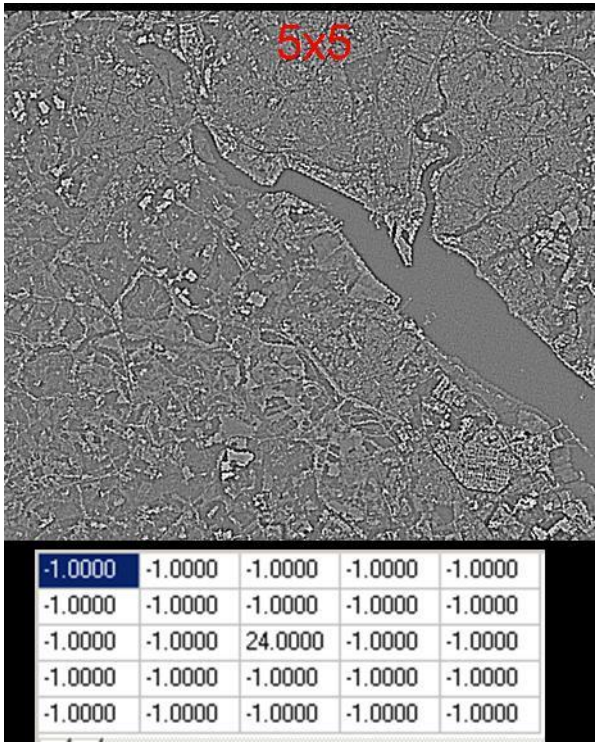
The bigger the kernel, the stronger the smoothing

https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/low_pass_filters.html#

High pass filters – Sharpening



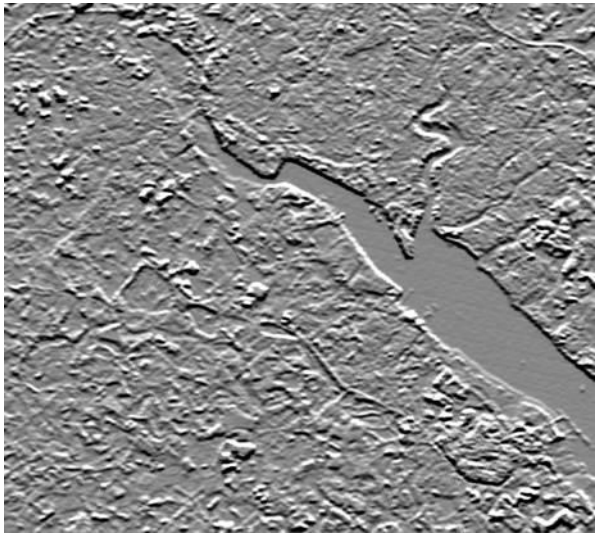




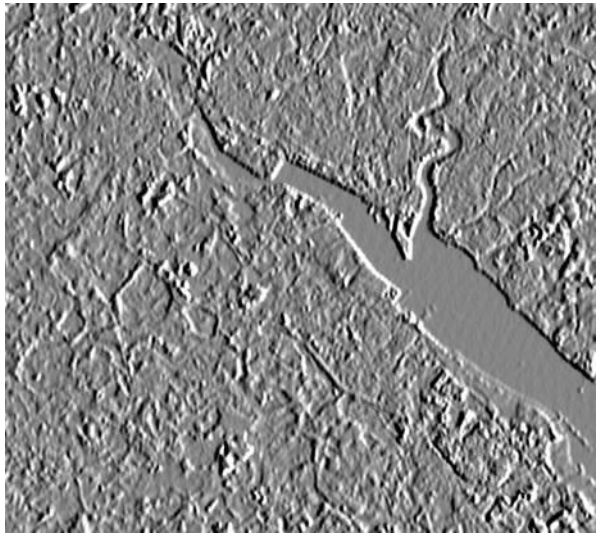
https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/high_pass_filters.html#

Directional filters – Edge detection

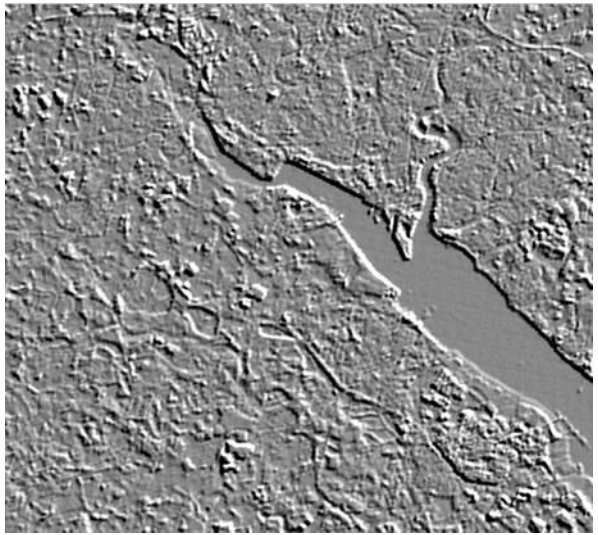
Horizontal



Vertical



Diagonal



https://www2.geog.soton.ac.uk/users/trevesr/obs/rseo/high_pass_filters.html#

Directional filters

Uses gradient filters – calcualtes the difference between neighbour pixels in some direction

Horizontal

(y-gradient filter)

1	1	1
0	0	0
-1	-1	-1

-1	-1	-1
0	0	0
1	1	1

Vertical

(x-gradient filter)

-1	0	1
-1	0	1
-1	0	1

1	0	-1
1	0	-1
1	0	-1

Diagonal filter

-1	-1	2
-1	2	-1
2	-1	-1

0	1	1
-1	0	1
-1	-1	0

! The sum of the kernel elements must be zero !

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1.3 Image fusion

Image fusion

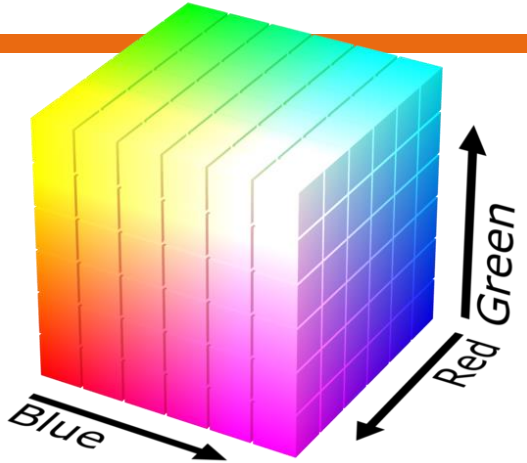
- Combine relevant information from multiple images to form a new more informative image
- E.g. combining lower-resolution multi-spectral images with a higher resolution panchromatic band => Pansharpening

  IF the difference in spatial resolution is not too different !
- Different techniques for image fusion exist e.g.
  - Colour based RGB-HIS
  - Brovey
  - Principal component analysis (PCA)

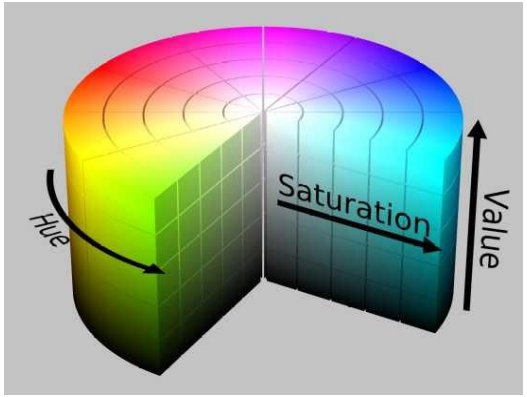
RGB - HIS

Different models to represent colours e.g.:

- RGB (Red, Green, Blue)
- HIS (Hue, Intensity/Value, Saturation)



https://commons.wikimedia.org/w/index.php?curid=3375025

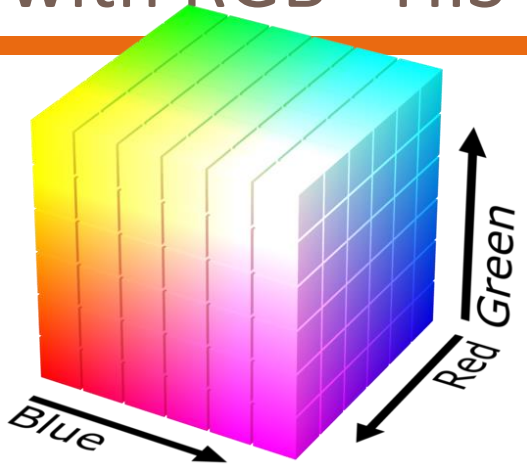


https://en.wikipedia.org/wiki/File:HSV_color_solid_cylinder_saturation_gray.png

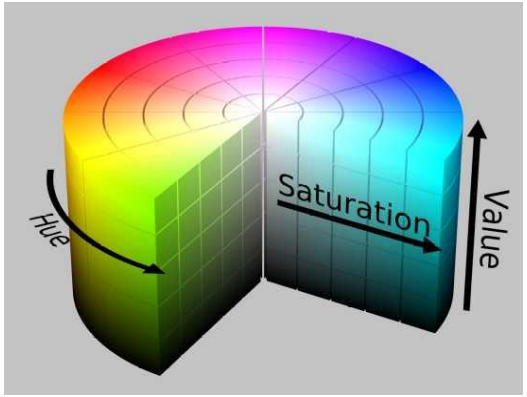
Pansharpening with RGB - HIS

- Combine high resolution panchromatic with colours of low resolution image (RGB)
- But panchromatic corresponds to **Intensity** (Value) – it does not use RGB

=> need to transform between RGB and HIS



https://commons.wikimedia.org/w/index.php?curid=3375025



https://en.wikipedia.org/wiki/File:HSV_color_solid_cylinder_saturation_gray.png

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Panchromatic
IKONOS P (1m)

Multispectral
IKONOS XS (4m)

1

Hue

~~Intensity~~

Saturation

2

3

XS + P (1m)

1. Convert multi-spectral bands from RGB to HIS colour space
2. Replace the intensity band with the panchromatic band
3. Convert back into RGB colour space

Summary

- Image enhancement includes:
  - Histogram operations
  - Spatial filter operations
  - Image fusion
- It improves the visual appearance of digital images for visual interpretation
- Enhancement is performed for a specific application