ComVis1U1

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- Image representation, distance, resizing
- Colour coding
- Histogram based transformations

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- **Image representation, distance, resizing**
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Image Representation

What is an image?

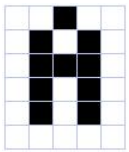
several possible definitions

- computer point of view : unsigned char table
- Physicist: observation of an environment by an optical sensor (2D digitized signal)
- Mathematician: the projection of a 3D space on a plane
- ...

Image Representation

The image model used here:

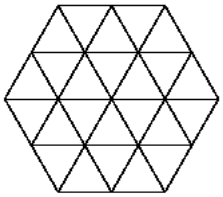
$$I : [0, L-1] \times [0, C-1] \rightarrow [0, M]^p \quad I = I(x, y)$$



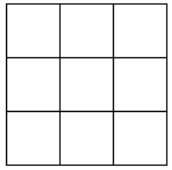
With :

- L: number of lines (height)
- C: number of columns (width)
- $M \in N^p$
- p = 1 for a luminance image (grey level)
- p = 3 for a color image (RGB, HSV, ...)

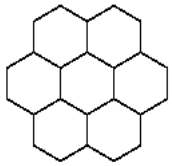
Pixels, neighbourhood, and distances



Triangle



Square



Hexagonal

Numerical representation of images

- black and white (1 bit) image
- colormap (n bits = 2^n colors (alpha may be one color))
- true colour (3 channels, 4 if alpha)

Size of an image (in octets):

width x height x nb_bits_per_pixel /8

Image files

+ Raster formats (pixel representation)
  - jpg, tiff, gif, png, bmp, ppm, …
+ Vector formats (feature based representation)
  - svg, cgm, …
+ Non compressed formats (bmp, …)

+ Lossless compression (jpg, png,…)
+ Lossy compression (jpg, png)

Image files

Example of Lossy Compression

Original Lena Image (12KB size)

Lena Image, Compressed (85% less information, 1.8KB)

Lena Image, Highly Compressed (96% less information, 0.56KB)

Distance between two pixels

Each pixel can be localised by its co-ordinates (x,y) into the image plane. Distances between pixels may be defined

A distance measure must have the following properties:

$$d(P,Q) > 0$$
$$d(P,Q) = d(Q,P)$$
$$d(P,Q) \leq d(P,R) + d(R,Q)$$

Principal distances

- Manathan distance

$$d_1(P,Q) = |x_p - x_q| + |y_p - y_q|$$

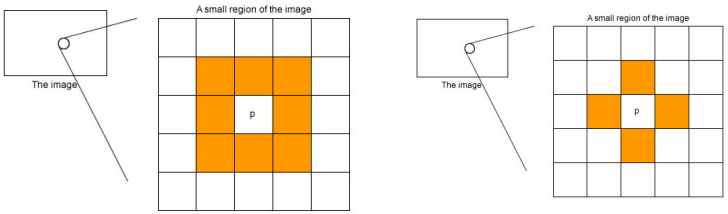
- Euclidian distance

$$d_2(P,Q) = \left\{(x_p - x_q)^2 + (y_p - y_q)^2\right\}^{0.5}$$

- Chessboard distance

$$d_\infty(P,Q) = \max(|x_p - x_q|, |y_p - y_q|)$$

Neighbourhood

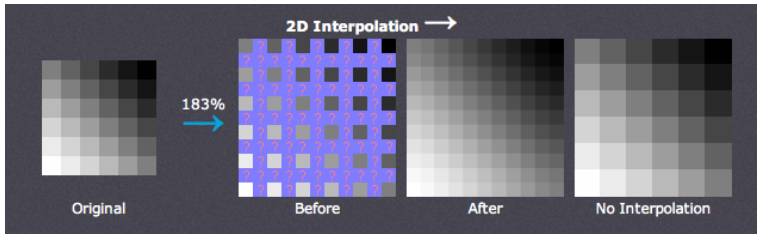


$$V_k(p) = \{Q : 0 < d(P,Q) \leq k\}$$

Image Scaling

In computer graphics, **image scaling** is the process of resizing a digital image

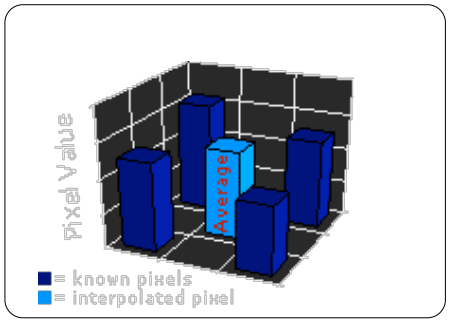
Image Scaling



bi-linear interpolation

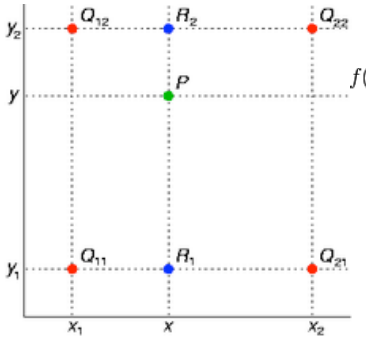
Knn

Image Scaling



bi-linear interpolation

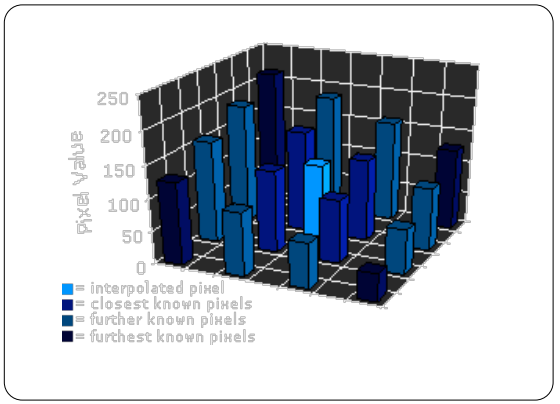
Image Scaling



$$f(x,y) \approx \frac{f(Q_{11})}{(x_2-x_1)(y_2-y_1)}(x_2-x)(y_2-y) + \frac{f(Q_{21})}{(x_2-x_1)(y_2-y_1)}(x-x_1)(y_2-y) + \frac{f(Q_{12})}{(x_2-x_1)(y_2-y_1)}(x_2-x)(y-y_1) + \frac{f(Q_{22})}{(x_2-x_1)(y_2-y_1)}(x-x_1)(y-y_1).$$

bi-linear interpolation

Image Scaling



bi-cubic interpolation

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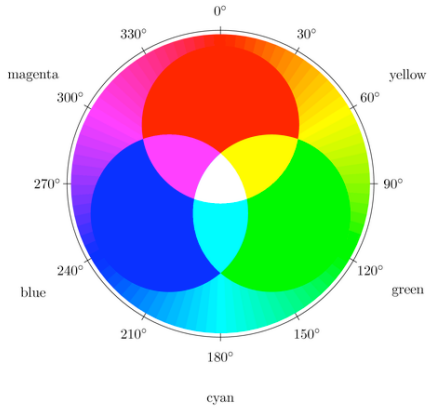
- **Colour coding**
- Histogram based transformations

Color images

- images are generally represented by a 3 components vector
- Many color spaces exist (RGB, HSV, Lab, YCrCb, YUV, ...)
- Only two of them are presented hereafter

Additif model RGB (Red, Green, Blue)



Additif model RGB (Red, Green, Blue)

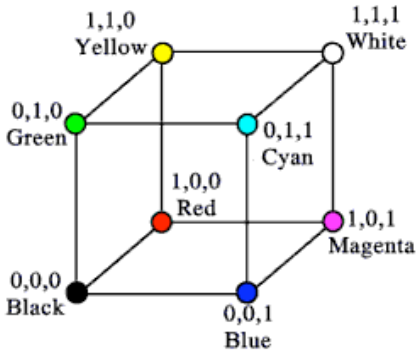


Image Representation

Additif model RGB (Red, Green, Blue)

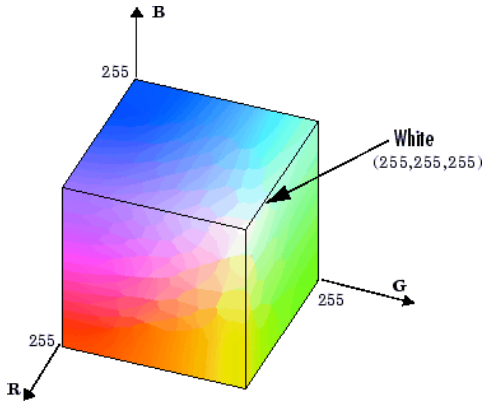
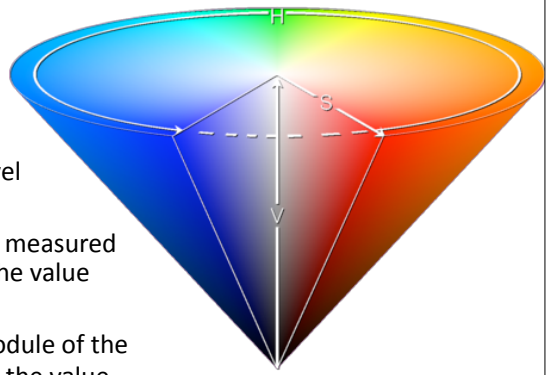


Image Representation

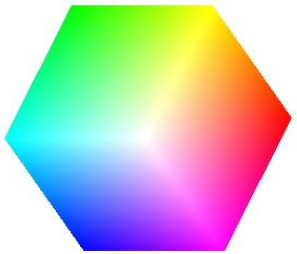
HSV model: [Hue, Saturation, Value]



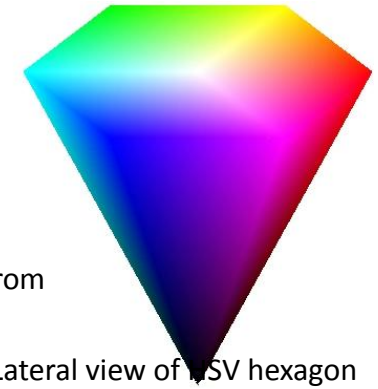
- **Value** is the grey level (luminance)
- **Hue** (wavelength) is measured by the angle along the value axis.
- **Saturation** is the module of the normal vector along the value axis
-

Image Representation

HSV model: [Hue, Saturation, Value]



chromatic cube observed from the white color



Lateral view of HSV hexagon

Vue latérale de l'hexacone HSV

Image Representation

HSV model: [Hue, Saturation, Value]

Constant brightness

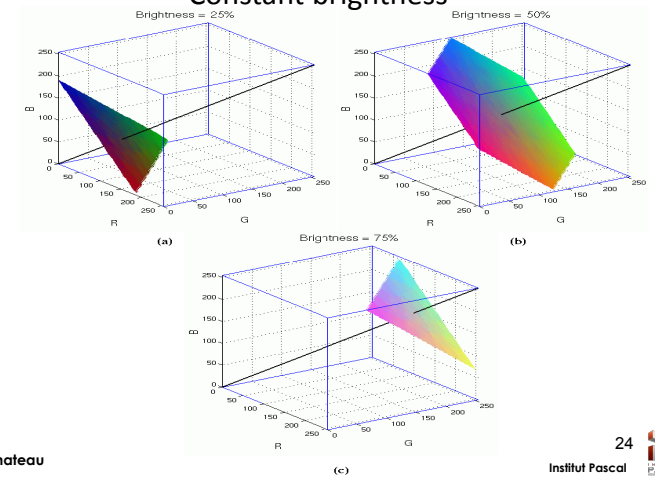


Image Representation

HSV model: [Hue, Saturation, Value]

Constant saturation

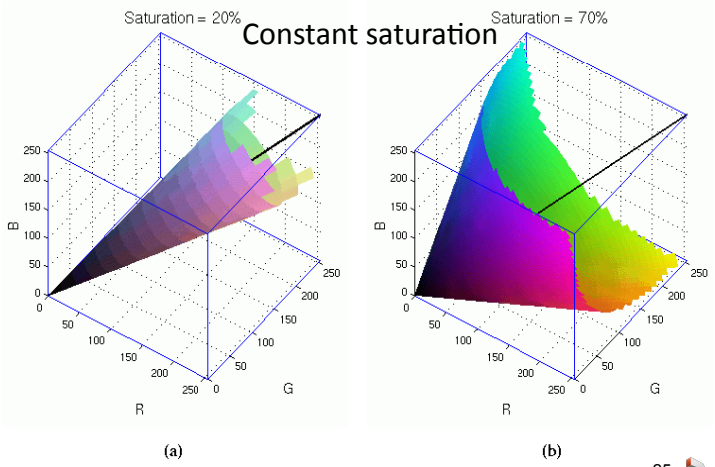


Image Representation

HSV model: [Hue, Saturation, Value]

Constant hue

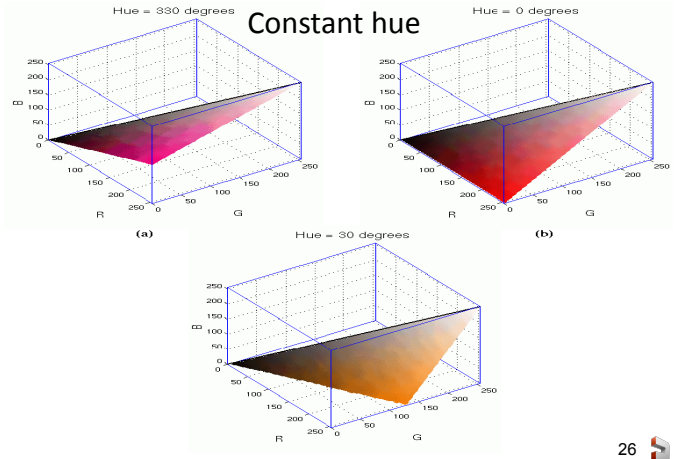


Image Representation

HSV decomposition

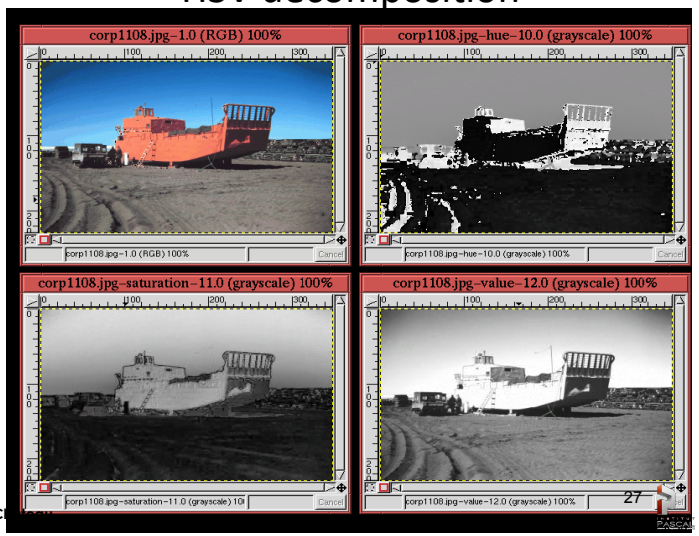


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Image Filtering

Filtering methods are divided into two main categories

- Global methods (the same function is applied on all the pixels)
- Local methods (the function applied to one pixel is related to it neighbourhood)

Histogram based transformations refers to global methods

Image Filtering: Global Methods

Histogram: a basic tool for global filtering

$$H(x) = Card\{\mathbf{p} : \mathtt{I}(\mathbf{p}) = x\}$$

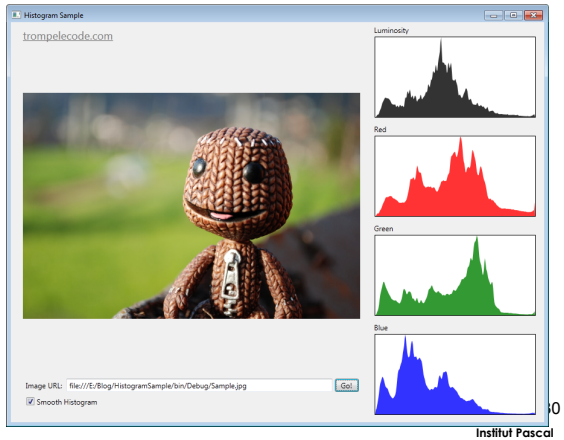


Image Filtering: Global Methods

Histogram: some examples

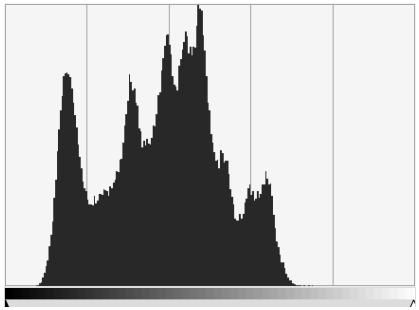
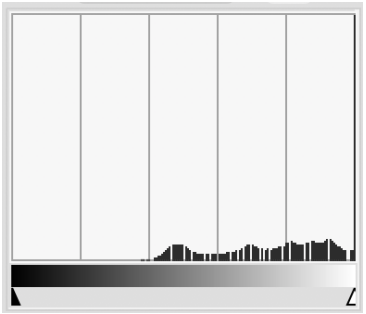


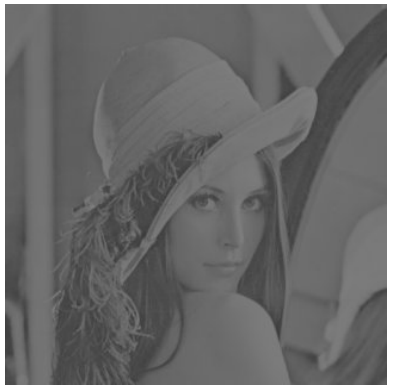
Image Filtering: Global Methods

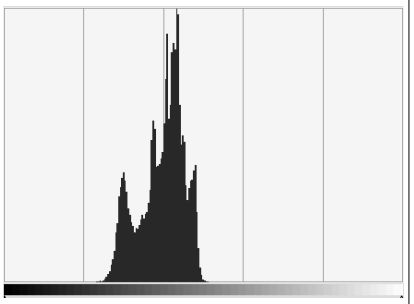
Histogram: some examples

Histogram: some examples

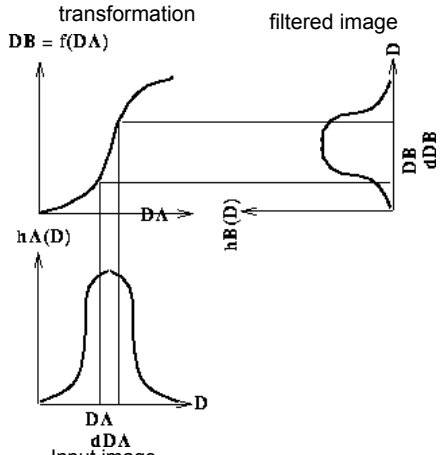


Histogram: some examples





Global transformations



histogram stretching

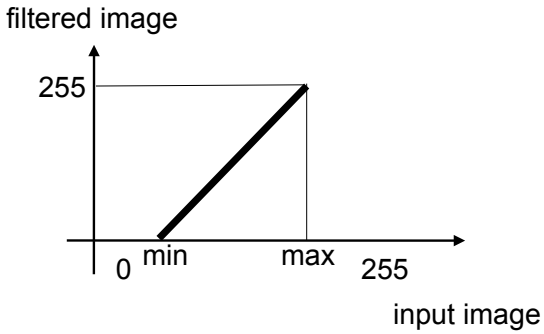


Image Filtering: Global Methods

histogram stretching

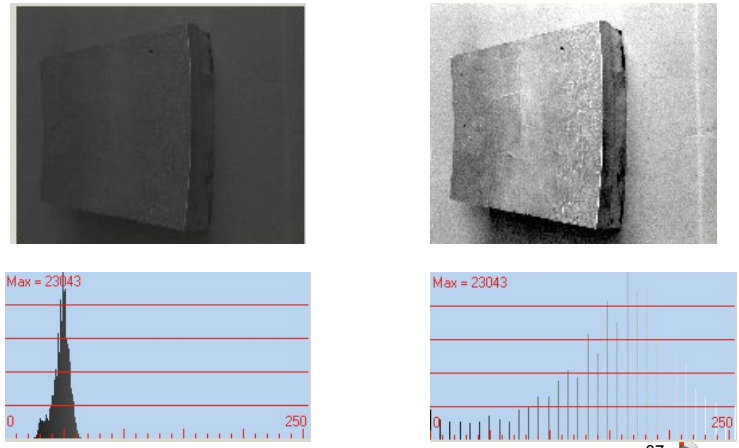


Image Filtering: Global Methods

limits of histogram stretching

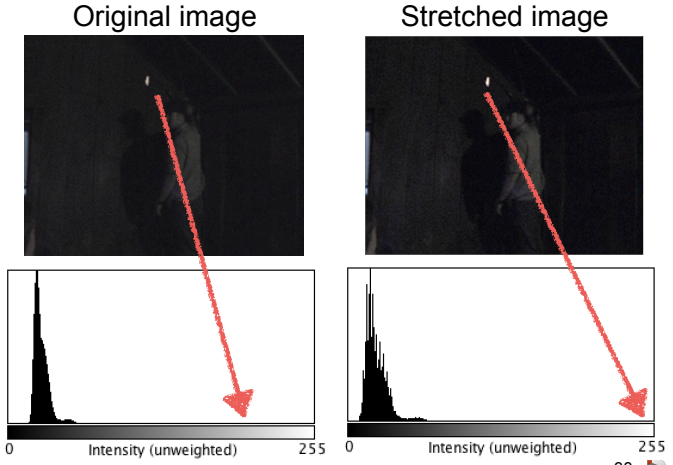


Image Filtering: Global Methods

histogram equalization

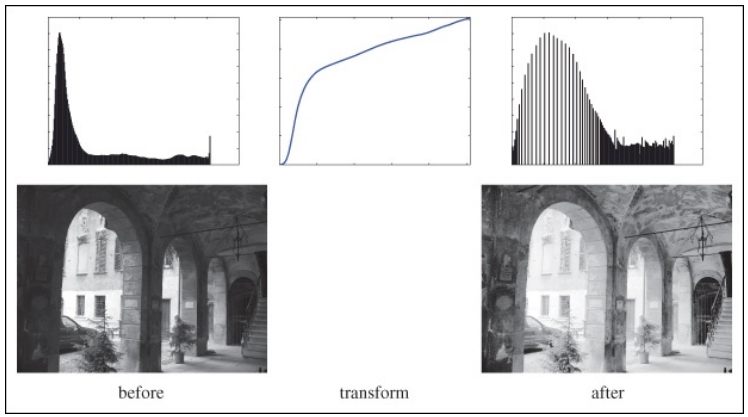
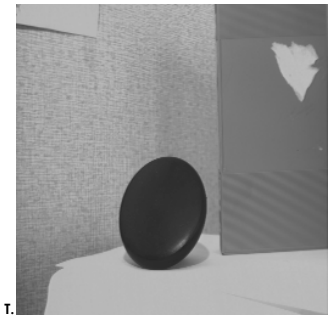


Image Filtering: Global Methods

histogram equalization

Image Filtering: Global Methods



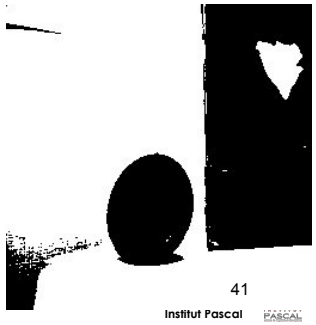


Image Filtering: Global Methods

And many other transformations:

- ✓stretching
- ✓equalization
- ✓Area extraction
- ✓Inverted image
- ✓Gamma correction
- ✓…
- ✓

Image Processing

Exercices

histogram stretching (0<=I(x)<=9 gray levels)
1) compute the original histogram
2) compute the stretched histogram

2	2	3	3	3
2	4	3	4	3
4	5	5	5	5
4	2	5	5	5
2	2	5	7	7

Image Processing

Exercices

Image scaling: (0<=I(x)<=9 gray levels)

1) give the general bi-linear expression
2) compute the 2x scaled image.

$$\begin{pmatrix} 3 & 5 & 3 \\ 4 & 8 & 6 \\ 2 & 5 & 4 \end{pmatrix}$$

Original image

$$\begin{pmatrix} 3 & . & 5 & . & 3 \\ . & . & . & . & . \\ 4 & . & 8 & . & 6 \\ . & . & . & . & . \\ 2 & . & 5 & . & 4 \end{pmatrix}$$

Interpolated image