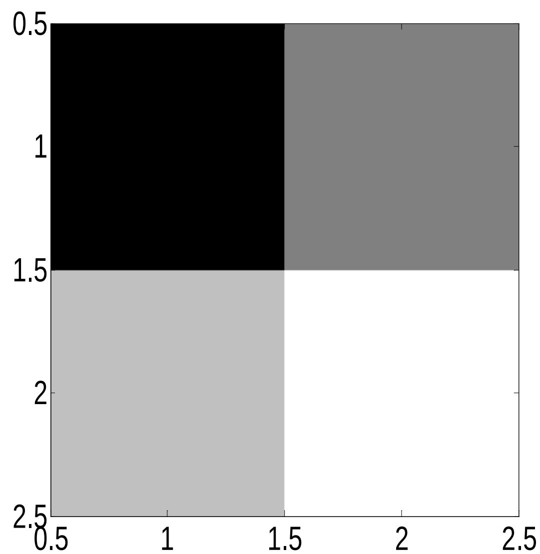
TW793: DIGITAL IMAGE PROCESSING

WHAT IS A (GRAY SCALE) DIGITAL IMAGE?

Matlab (command window) instructions:

```
>> A = [0 128; 192 255]                                    ENTER
 A =
      0      128
      192    255
>> image( A )                                              ENTER
>> colormap( gray ( 256 ) )                                ENTER
>> axis image                                              ENTER
```



A gray scale digital image is a

- **matrix $f(x, y)$, where**
- **f is the intensity (gray scale value) of the image f at row x and column y**
- **and each coordinate (x, y) is represented by a pixel, where**
- **the pixel is coloured black if $f(x, y) = 0$ and coloured white if $f(x, y) = L - 1$**

(for the example on the previous page we have that $L = 256$)

Matlab instructions:

```
>> a = A(2,1)                                  ENTER

 a =
      192

>> b = A(1,2)                                  ENTER

 b =
      128
```

When `colormap( gray ( 256 ) )` is selected and an image (matrix) is displayed in Matlab with the `image` instruction, each entry (pixel) is internally "converted" to the `uint8` (unsigned 8-bit integer) data type. This implies that each pixel (matrix entry) is represented with an 8-bit byte, which implies $L = 2^8 = 256$ possible intensity values (gray scales). The instruction `imagesc` is the same as `image`, except that the data is scaled to use the full colormap, which can come in very handy. Images read into memory from a storage device are often in `uint8` format.

In order to be able to manipulate an `uint8` matrix (image) in double precision arithmetic, the matrix has to be converted into the `double` data type with `B = double( A )`. The inverse operation is achieved with `A = uint8( B )`. The Matlab default is `double`.

An image file, e.g. "lenna256.jpg" (JPEG format) can be displayed with the following Matlab instruction (IP Toolbox)

```
>> imshow( 'lenna256.jpg' )
```

ENTER

lenna256.jpg

To manipulate this image in Matlab, the following instructions are needed

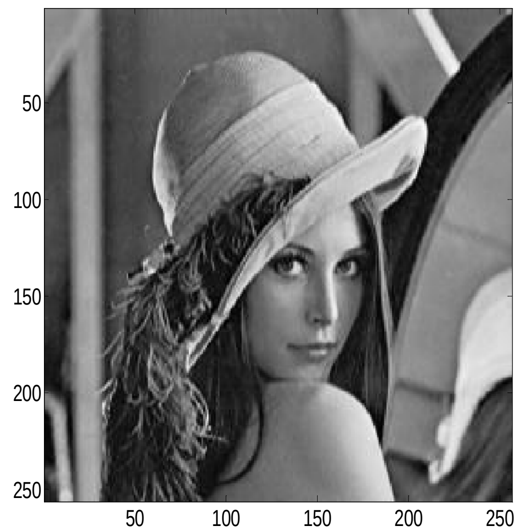
```
>> X = imread( 'lenna256.jpg' );                ENTER
>> XX = double( X );                            ENTER
```

The variable `X` now represents a matrix that can be accessed/manipulated

```
>> mn = min( min( XX ) )                        ENTER
 mn =
      0
>> mx = max( max( XX ) )                        ENTER
 mx =
      239
>> sz = size( XX )                              ENTER
 sz =
      256   256
>> entry = XX(100,150)                          ENTER
 entry =
         173
```

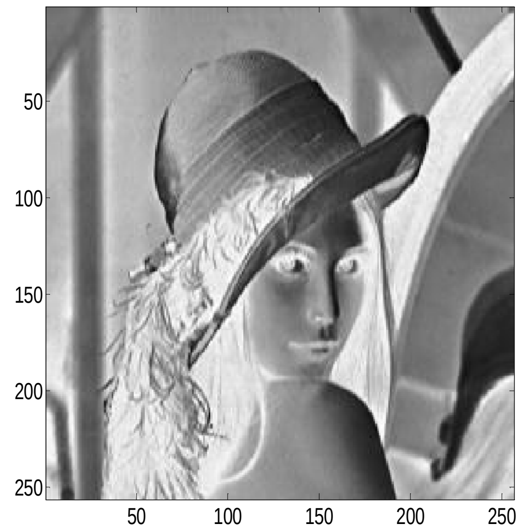
The matrix XX can again be displayed with the instructions

```
>> colormap( gray ( 256 ) );     ENTER
>> imagesc( XX )                 ENTER
>> axis image                    ENTER
```



We can now, e.g., calculate and display the negative of the image with the instructions

```
>> Y = max( max( XX ) ) - XX;    ENTER
>> colormap( gray ( 256 ) );     ENTER
>> imagesc( Y )                  ENTER
>> axis image                    ENTER
```



Any matrix can be saved to a disk. The following instruction saves the variable Y **in the current directory as the Matlab file "lenna256neg.mat":**

```
>> save lenna256neg.mat Y                                    ENTER
```

During subsequent Matlab sessions this file can be retrieved and automatically reassigned to the variable Y **with the instruction**

```
>> load lenna256neg.mat                                      ENTER
```

The matrix Y **can also be saved in a variety of common image file formats, like JPEG, BMP, etc., with instructions like**

```
>> imwrite(Y,gray(256),'lenna256neg.bmp','bmp')
```

The file "lenna256neg.bmp" (BMP format) can be displayed with the Matlab instruction (IP Toolbox): `>> imshow('lenna256neg.bmp')`

lenna256neg.bmp

In order to obtain a list of all the available Matlab functions in the Image Processing (IP) Toolbox, give the instruction: `>> help images`

E.g., the negative of an image can also be obtained with the `imcomplement` function, i.e.: `>> Y = imcomplement( X );`

For a demonstration of the IP Toolbox, enter `demo` in the command window and double-click on "Toolboxes" and then "Image Processing"...

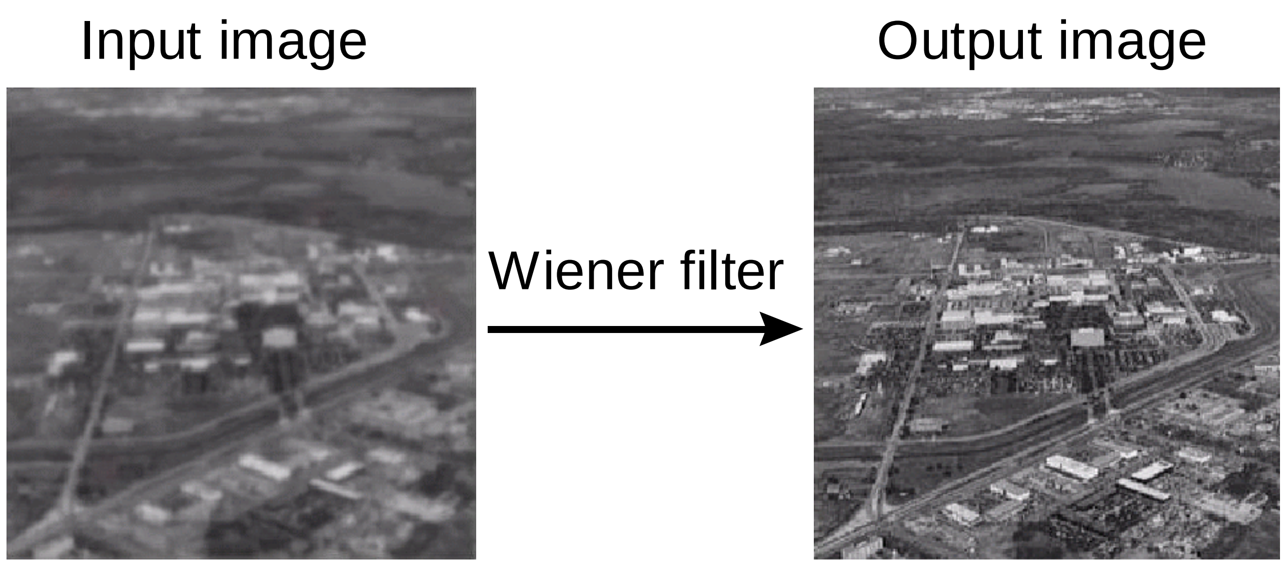
WHAT IS DIGITAL IMAGE PROCESSING?

1 **Input image** ⟶ **Processing** ⟶ **Output image**

- **Image enhancement and restoration**

Input ⟶ **Filter** ⟶ **Output**

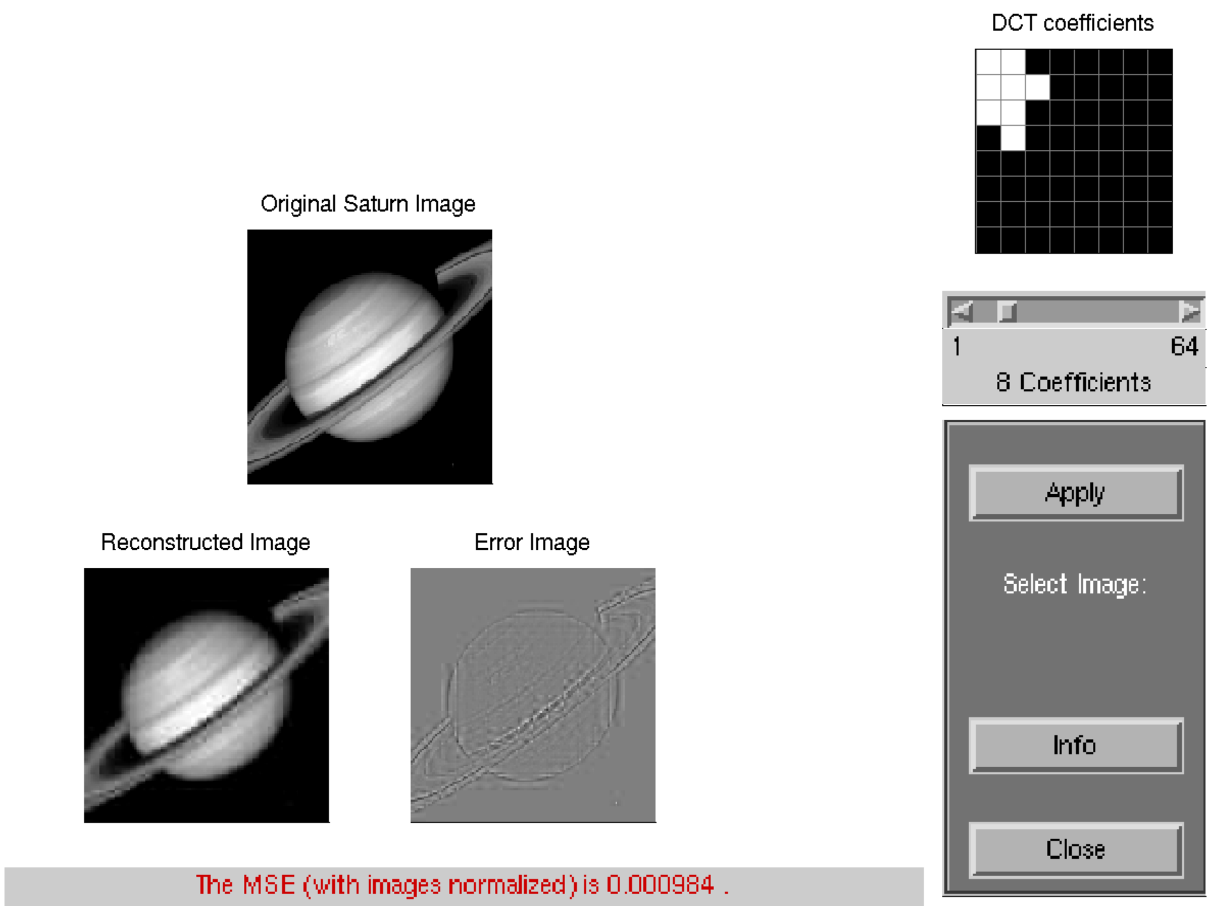
Input ⟶ **Transform** ⟶ **Filter** ⟶ **Inverse transform** ⟶ **Output**



- **Image compression**

Input ⟶ **Coding** ⟶ **Code** ⟶ **Decoding** ⟶ **Output**

JPEG Demo: 8 DCT coefficients retained

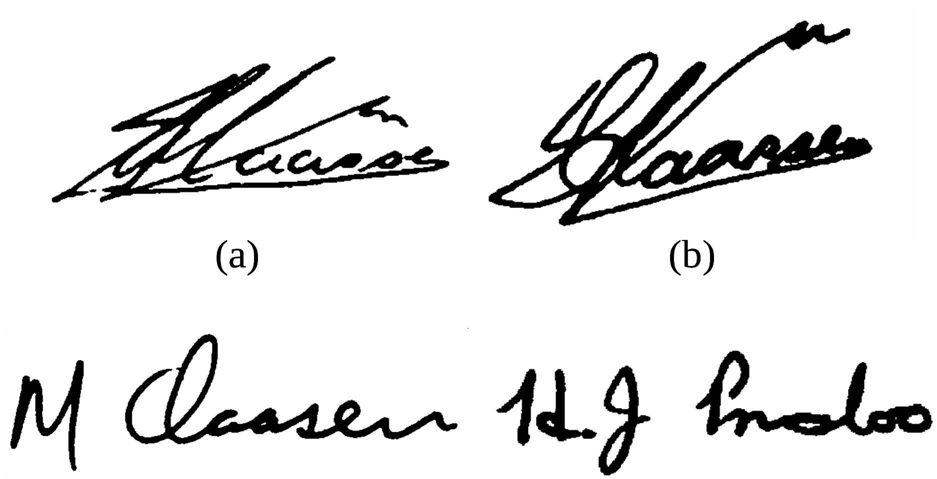


2 Image ⟶ Processing ⟶ Features ⟶ Recognition

- Object recognition

Image ⟶ Segmentation ⟶ Object
⟶ Representation and description ⟶ Features ⟶ Recognition

Example: Signature verification



(a) (b) (c) (d)

(the authentic signature is (a))

OVERVIEW OF COURSE

- Fourier analysis
- Image enhancement
  - Spatial domain (Ch. 3)
  - Fourier domain (Ch. 4)
- Image restoration (Ch. 5)
- Colour IP (Ch. 6)

Wavelets (Ch. 7)

- Compression (Ch. 8)
- Morphological IP (Ch. 9)
- Pattern Recognition
  - Segmentation (Ch. 10)
  - Representation & description (Ch. 11)

  Object recognition (Ch. 12)