Department of Computer Science
Digital Image Processing

N. Komodakis, Course instructor

Autumn 2022

Image Resolution Manipulation

The task of this assignment is to assess the consequences of applying image sub-sampling and up-sampling techniques on textured images. You will be using a small database of images to study the correlation between errors due to sub-sampling and the texture characteristics of an image. Every image, defined as $\{x(m,n), 1 \leq m \leq M, 1 \leq n \leq N\}$ will be initially sub-sampled using a scale factor of ≤ 1 and subsequently up-sampled using interpolation to restore it to its original size. Let $\{y(m,n), 1 \leq m \leq M, 1 \leq n \leq N\}$ be the restored image.

We define the **mean approximation error** between the original and restored images as follows:

$$E = \frac{1}{S}\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}(x(m,n) - y(m,n))^2}$$

where

$$S = \sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}x(m,n)^2}$$

As metrics for the image characteristics, we consider the mean local horizontal and vertical differences of pixel elements, which are defined as:

$$G_h = \frac{1}{S}\sqrt{\sum_{m=1}^{M}\sum_{n=2}^{N}(x(m,n) - x(m,n-1))^2}$$

$$G_v = \frac{1}{S}\sqrt{\sum_{m=2}^{M}\sum_{n=1}^{N}(x(m,n) - x(m-1,n))^2}$$

From the two mean local differences we consider the largest to be the **local difference** of an image:

$$G = max(G_h, G_v)$$

Based on the aforementioned image characteristics and error metrics, the tasks for this assignment, are the following:

1. **Sub-sample and up-sample using Nearest Neighbour**

   (a) Implement a function, under the name my_imresize_NN(), that performs image sub-sampling/up-sampling using the method of *Nearest Neighbour*. The function inputs are:

   - 'I', the initial image that has to be sub-sampled or up-sampled.
   - 'a', the scaling factor.

- 'op', the functionality argument. This argument defines the operation that has to be applied to the input image, and can have two value options, (a) *sub-sampling*, (b) up-sampling .

(b) Perform the same operations using the build-in Matlab function, *imresize()* using the same input image and scaling factor parameters.

(c) Compare the restored (up-sampled) images from the two functions (your function and Matlab's), based on the (a) *Mean approximation error* (E), (b) *local difference metric*, G), and comment on the results.

2. **Sub-sample using Nearest Neighbor and up-sample using Bi-linear Interpolation**

(a) Implement a function, under the name *my_imresize_Bilinear()*, that performs the aforementioned operations. The inputs to the function are:

- 'I', the initial image that has to be sub-sampled or up-sampled.
- 'a', the scaling factor.
- 'op', the functionality argument. This argument defines the operation that has to be applied to the input image, and can have two value options, (a) *sub-sampling*, (b) up-sampling .

(b) Perform the same operations using the build-in Matlab function, *imresize()* using the same input image and scaling factor parameters.

(c) Compare the restored (up-sampled) images from the two functions (your function and Matlab's), based on the (a) *Mean approximation error* (E), (b) *local difference metric*, G), and comment on the results.

3. Call the Matlab function *imresize()* to perform sampling on the original image based on the *Nearest Neighbour* method, using the mode of *Anti-aliasing*, and the reconstruct the image to its original size using the same function, again with the*Nearest Neighbour* approach.

   Compare the restored image with the original image, as well as with the restored image from the same operation without applying *Anti-aliasing*. For the comparison, use the same metrics from the previous parts.

4. Perform all the operations that you previously defined on every image of the database, and comment whether the texture of the image plays a role on the restoration quality.

Suggestions : We recommend you to initially scale the image values (intensities) in the range [0, 1].

Useful Matlab functions : *imageDatastore, imresize*.

The image database can be found in : http://www.csd.uoc.gr/ hy371/images/Brodatz.7z.

Required submission files:

1. Your code implementation with comments.
2. your report, in .pdf format. Do not forget to include captions under every figure.