

Lecture No: 5 Image zooming**Image zooming**

Is a process that used to enlarge the data of the image and it is done by using many ways:

Zero order hold

is performed by repeating previous pixel values, thus creating a blocky effect as in the following figure

- **Zooming by repetition: A horizontal zooming** (here taken as enlargement) Y ($N \times KM$) of an image x ($N \times M$) can be done by **repeating** the image columns K times (with h-zooming factor $K=2$).

$$x = \begin{bmatrix} a & b & c \\ d & e & f \\ s & t & u \end{bmatrix} \rightarrow y = \begin{bmatrix} a & a & b & b & c & c \\ d & d & e & e & f & f \\ s & s & t & t & u & u \end{bmatrix}$$

- **Vertical zooming z** ($LN \times M$) can be done similarly:

$$x = \begin{bmatrix} a & b & c \\ d & e & f \\ s & t & u \end{bmatrix} \rightarrow z = \begin{bmatrix} a & b & c \\ a & b & c \\ d & e & f \\ d & e & f \\ s & t & u \\ s & t & u \end{bmatrix}$$

with v-zooming factor L=2

- **General zooming w** (LN×KM) can be done by **repeating** rows and columns:

with L=K=2

$$x = \begin{bmatrix} a & b & c \\ d & e & f \\ s & t & u \end{bmatrix} \rightarrow w = \begin{bmatrix} a & a & b & b & c & c \\ a & a & b & b & c & c \\ d & d & e & e & f & f \\ d & d & e & e & f & f \\ s & s & t & t & u & u \\ s & s & t & t & u & u \end{bmatrix}$$

First_Order Hold Zooming by Average: is performed by finding linear interpolation between adjacent pixels, i.e., finding the average value between two pixels and use that as the pixel value between those two, we can do this for the rows first as follows:

We enlarge an image x (N×M) horizontally by making a new column between any 2 adjacent columns that equals their average to get image y (N×(2M-1)):

$$x = \begin{bmatrix} a & b & c \\ d & e & f \\ s & t & u \end{bmatrix} \rightarrow y = \begin{bmatrix} a & (a+b)/2 & b & (b+c)/2 & c \\ d & (d+e)/2 & e & (e+f)/2 & f \\ s & (s+t)/2 & t & (t+u)/2 & u \end{bmatrix} \text{ (h-zooming) } \rightarrow$$

Followed by v-zooming on **y**:

$$z = \begin{bmatrix} a & (a+b)/2 & b & (b+c)/2 & c \\ (a+d)/2 & (a+b+d+e)/4 & (b+e)/2 & (b+c+e+f)/4 & (c+f)/2 \\ d & (d+e)/2 & e & (e+f)/2 & f \\ (d+s)/2 & (d+e+s+t)/4 & (e+t)/2 & (e+f+t+u)/4 & (f+u)/2 \\ s & (s+t)/2 & t & (t+u)/2 & u \end{bmatrix}$$

If **x** is $N \times M$, then **z** is $(2N-1) \times (2M-1)$. This averaging can be repeated.

For example

Original Image

8	4	8
4	8	4
8	2	8

Array Image with Rows Expanded

8	6	4	6	8
4	6	8	6	4
8	5	2	5	8

The first two pixels in the first row are averaged $(8+4)/2=6$, and this number is inserted between those two pixels. This is done for every pixel pair in each row.

Next, take result and expanded the columns in the same way as follows:

Image with rows and columns expanded

8	6	4	6	8
6	6	6	6	6
4	6	8	6	4
6	5.5	5	5.5	6
8	5	2	5	8

This method allows us to enlarge an $N \times N$ sized image to a size of $(2N-1) \times (2N-1)$ and be repeated as desired.

Zooming by Filtering (Convolution):

This process requires a mathematical process to enlarge an image. This method required two steps:

1. Extend the image by adding rows and columns of zeros between the existing rows and columns.
2. Perform the convolution.
image is extended as follows:

First we expand the image $x (N \times M)$ through adding zero rows and zero columns:

$$x = \begin{bmatrix} a & b & c & d \\ e & f & g & h \\ p & q & r & s \\ t & u & v & w \end{bmatrix} \rightarrow y = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & a & 0 & b & 0 & c & 0 & d & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & e & 0 & f & 0 & g & 0 & h & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & p & 0 & q & 0 & r & 0 & s & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & t & 0 & u & 0 & v & 0 & w & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Then we filter this new image y [which is $(2N + 1) \times (2M + 1)$] with a 2D filter (mask) s of dimension $n \times m$; hence, a 2D discrete convolution results: