Medical Imaging Processing

Image Zooming

By

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Image Zooming

The zoom process can be done in numerous ways:

1. Zero-Order Hold.   2. First _Order Hold. 3. Convolution.

1. **Zero-Order hold:** is performed by repeating previous pixel values, thus creating a blocky effect.

Example: if we have an image of size(n*n), we can zooming it using zero order method with size (2n)*(2n) where N is a row and column number.

a-Original image   b- cropped image   c- zoomed image
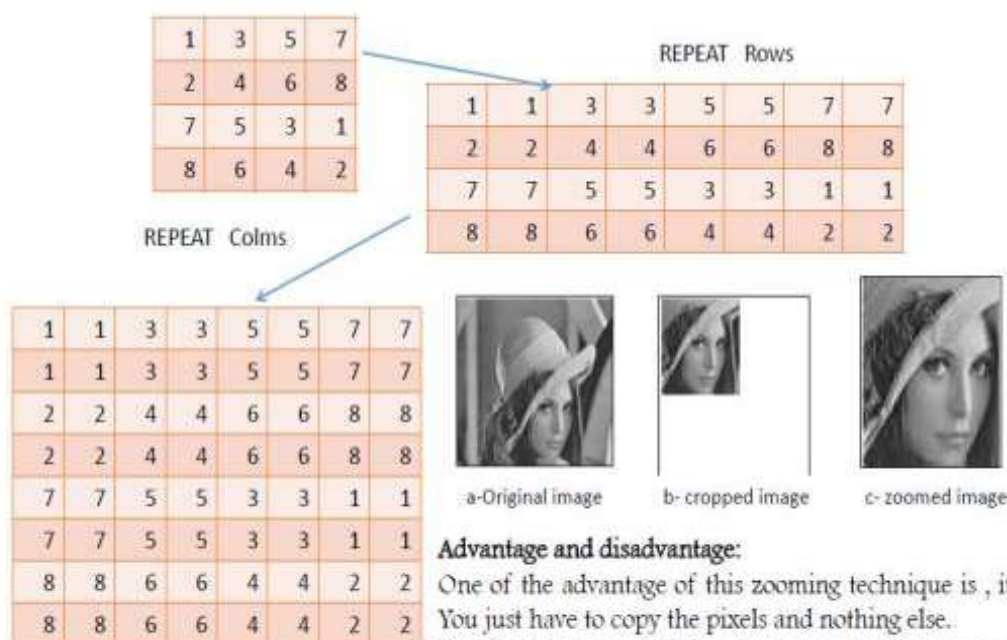
Advantage and disadvantage:
One of the advantage of this zooming technique is , it is very simple. You just have to copy the pixels and nothing else.
The disadvantage of this technique is that image got zoomed but the output is very blurry. And as the zooming factor increased , the image got more and more blurred. That would eventually result in fully blurred image.

2. **First _Order Hold:**   is performed by finding linear interpolation between a 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:

Original Image Array

$$\begin{bmatrix} 8 & 4 & 8 \\ 4 & 8 & 4 \\ 8 & 2 & 8 \end{bmatrix}$$

Image with Rows Expanded

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

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

$$\begin{bmatrix} 8 & 6 & 4 & 6 & 8 \\ 6 & 6 & 6 & 6 & 6 \\ 4 & 6 & 8 & 6 & 4 \\ 6 & 5.5=6 & 5 & 5.5=6 & 6 \\ 8 & 5 & 2 & 5 & 8 \end{bmatrix}$$

3. **The Convolution Process**:

This method requires a mathematical process to enlarge an image. This method required <u>**two**</u> steps:

1. <u>**Extend the image by adding rows and columns of zeros**</u>

Original Image Array

$$\begin{bmatrix} 3 & 5 & 7 \\ 2 & 7 & 6 \\ 3 & 4 & 9 \end{bmatrix}$$

Image extended with zeros

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 5 & 0 & 7 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 7 & 0 & 6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 4 & 0 & 9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

2. Perform the convolution.

Next, we use convolution mask, which is slide a cross the extended image, and perform simple arithmetic operation at each pixel location.

Convolution mask for First-order hold

$$\begin{bmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{2} & 1 & \frac{1}{2} \\ \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \end{bmatrix}$$

The convolution process requires us to overlay the mask on the image, multiply the coincident values and sum all these results. This is equivalent to finding the vector inner product of the mask with underlying sub image. The vector inner product is found by overlaying mask on subimage. Multiplying coincident terms, and summing the resulting products. For example, if we put the mask over the upper-left corner of the image, we obtain (from right to left, and top to bottom): 1/4(0) +1/2(0) +1/4(0) +1/2(0) +1(3) +1/2(0) + 1/4(0) +1/2(0) +1/4(0)=3

 **Note** that the existing image values do not change. The next step is to

slide the mask over by on pixel and repeat the process, as follows:

1/4(0) +1/2(0) +1/4(0) +1/2(3) +1(0) +1/2(5) + 1/4(0) +1/2(0) +1/4(0)

=4

When the end of the row is reached, the mask is moved down one row, and the process is repeated row by row. This procedure has been performed on the entire image, the process of **sliding, multiplying and summing is called convolution.**

Note that the output image must be put in a separate image array called a buffer, so that the existing values are not overwritten during the convolution process.
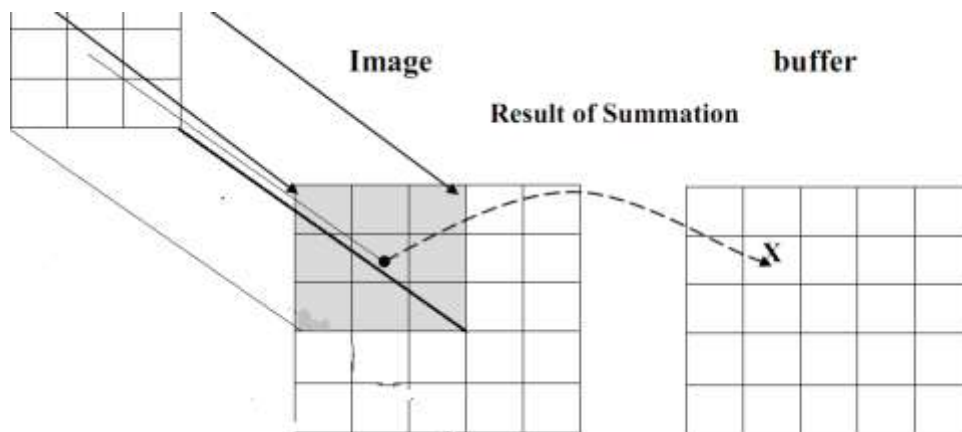
a. Overlay the convolution mask in the upper-left corner of the image. Multiply coincident terms, sum, and put the result into the image buffer at the location that corresponds to the masks current center, which is (r,c)=(1,1).
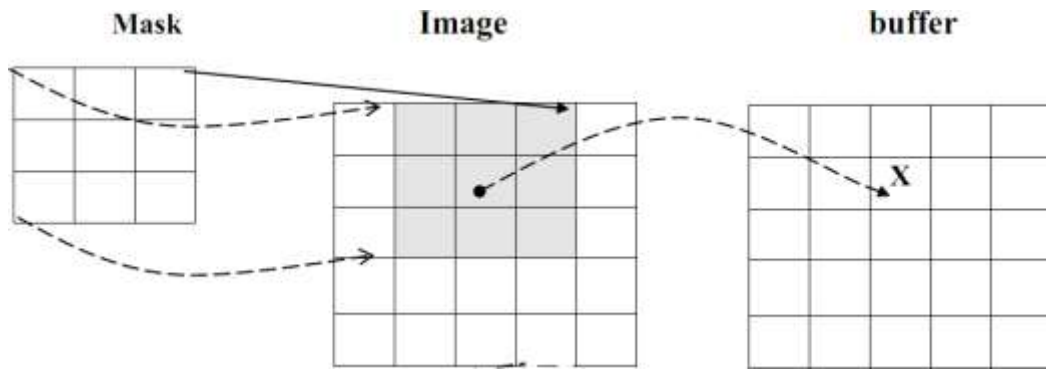
b. Move the mask one pixel to the right , multiply coincident terms sum , and place the new results into the buffer at the location that corresponds to the new center location of the convolution mask
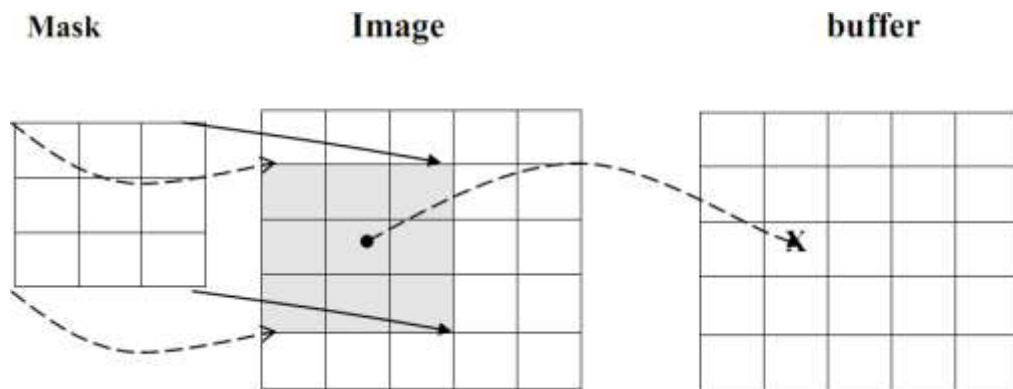
which is now at (r,c)=(1,2), continue to the end of the row.

c. Move the mask down on row and repeat the process until the mask is convolved with the entire image. Note that we lose the outer row(s) and columns(s).

At this point a good question would be Why we use this convolution method when it require, so many more calculation than the basic averaging of the neighbors method?

The answer :is that many computer boards can perform convolution in hardware, which is generally very fast, typically much faster than applying a faster algorithm in software.

Bubble Sheet Questions

Q1 . Which method of image zooming repeats previous pixel values, creating a blocky effect?
　　a. First-Order Hold
　　b. Convolution
　　c. Zero-Order Hold
　　d. Linear Interpolation

Answer: c. Zero-Order Hold

Q2 . What is the purpose of First-Order Hold in image zooming?
　　a. To repeat pixel values
　　b. To create a blocky effect
　　c. To find the average value between adjacent pixels
　　d. To perform convolution with a mask

Answer: c. To find the average value between adjacent pixels

Q3 . Which step is NOT part of the convolution process in image zooming?
　　a. Overlay the convolution mask in the upper-left corner of the image.
　　b. Move the mask one pixel to the right and multiply coincident terms.
　　c. Move the mask down one row and repeat the process until the mask is convolved with the entire image.
　　d. Extend the image by adding rows and columns of zeros.

Answer: d. Extend the image by adding rows and columns of zeros

Q4 . Why is the convolution method used in image zooming, despite requiring more calculations than basic averaging of neighbors?
　　a. Convolution produces blocky effects.
　　b. Convolution is easier to implement in hardware.
　　c. Convolution is faster than other software-based methods.
　　d. Convolution is used for gray-level reduction.

Answer: b. Convolution is easier to implement in hardware.

Q5 . Which image zooming method can also achieve zero-order hold by extending the image with zeros?
　　a. Linear Interpolation
　　b. Convolution
　　c. First-Order Hold
　　d. None of the above

Answer: b. Convolution

Not only first-order hold be performed via convolution, but zero-order hold can also achieved by extending the image with zeros and using the following convolution mask.

Zero-order hold convolution mask

$$\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$$

Note that for this mask we will need to put the result in the pixel location corresponding to the lower-right corner because there is no center pixel.