Computer Vision-IT416

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Concept of Zooming.

Aspect ratio

Another important concept with the pixel resolution is aspect ratio.

Aspect ratio is the ratio between width of an image and the height of an image. It is commonly explained as two numbers separated by a colon (8:9). This ratio differs in different images, and in different screens. The common aspect ratios are:

1.33:1, 1.37:1, 1.43:1, 1.50:1, 1.56:1, 1.66:1, 1.75:1, 1.78:1, 1.85:1, 2.00:1, e.t.c

Advantage

Aspect ratio maintains a balance between the appearance of an image on the screen, means it maintains a ratio between horizontal and vertical pixels. It does not let the image to get distorted when aspect ratio is increased.

For example

If you are given an image with aspect ratio of 6:2 of an image of pixel resolution of 480000 pixels given the image is an gray scale image.

And you are asked to calculate two things.

- Resolve pixel resolution to calculate the dimensions of image
- Calculate the size of the image

Solution:

Given:

Aspect ratio: c:r = 6:2

Pixel resolution: c * r = 480000

Bits per pixel: grayscale image = 8bpp

Find:

Number of rows = ?

Number of cols = ?

Solving first part:

Equation 1. c:r = 6:2 → c = 6 r / 2

Equation 2. c = 480000/r

Comparing both equations → $\frac{6r}{2} = \frac{480000}{r}$

$$r^2 = \sqrt{\frac{480000*2}{6}}$$

That gives r = 400.

That gives $r = 400$.

Put r in equation 1, we get → $c = 1200$.

So rows = 400 cols = 1200.

Solving 2nd part:

Size = rows * cols * bpp

Size of image in bits = 400 * 1200 * 8 = 3840000 bits

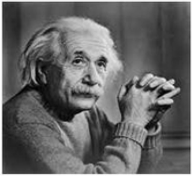
Size of image in bytes = 480000 bytes

Size of image in kilo bytes = 48 kb (approx).

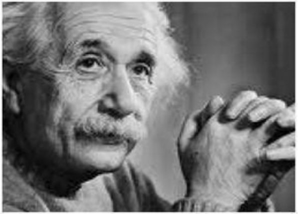
Zooming

Zooming simply means enlarging a picture in a sense that the details in the image became more visible and clear. Zooming an image has many wide applications ranging from zooming through a camera lens, to zoom an image on internet e.t.c.

For example



is zoomed into



You can zoom something at two different steps.

The first step includes zooming before taking an particular image. This is known as pre processing zoom. This zoom involves hardware and mechanical movement.

The second step is to zoom once an image has been captured. It is done through many different algorithms in which we manipulate pixels to zoom in the required portion.

We will discuss them in detail in the next tutorial.

Optical Zoom vs digital Zoom

These two types of zoom are supported by the cameras.

Optical Zoom:

The optical zoom is achieved using the movement of the lens of your camera. An optical zoom is actually a true zoom. The result of the optical zoom is far better then that of digital zoom. In optical zoom, an image is magnified by the lens in such a way that the objects in the image appear to be closer to the camera. In optical zoom the lens is physically extend to zoom or magnify an object.

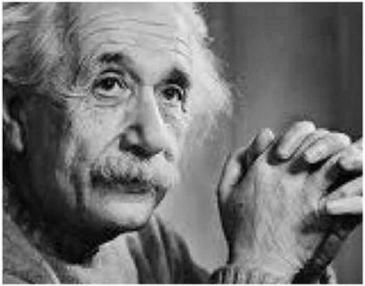
Digital Zoom:

Digital zoom is basically image processing within a camera. During a digital zoom, the center of the image is magnified and the edges of the picture got crop out. Due to magnified center, it looks like that the object is closer to you.

During a digital zoom, the pixels got expand , due to which the quality of the image is compromised.

The same effect of digital zoom can be seen after the image is taken through your computer by using an image processing toolbox / software, such as Photoshop.

The following picture is the result of digital zoom done through one of the following methods given below in the zooming methods.



Now since we are leaning digital image processing, we will not focus, on how an image can be zoomed optically using lens or other stuff. Rather we will focus on the methods, that enable to zoom a digital image.

Zooming methods:

Although there are many methods that does this job, but we are going to discuss the most common of them here.

They are listed below.

- Pixel replication or (Nearest neighbor interpolation)
- Zero order hold method
- Zooming K times

All these three methods are formally introduced in the next tutorial.

Method 1: Pixel replication:

Introduction:

It is also known as Nearest neighbor interpolation. As its name suggest, in this method, we just replicate the neighboring pixels. As we have already discussed in the tutorial of Sampling, that zooming is nothing but increase amount of sample or pixels. This algorithm works on the same principle.

Working:

In this method we create new pixels form the already given pixels. Each pixel is replicated in this method n times row wise and column wise and you got a zoomed image. Its as simple as that.

For example:

if you have an image of 2 rows and 2 columns and you want to zoom it twice or 2 times using pixel replication, here how it can be done.

For a better understanding, the image has been taken in the form of matrix with the pixel values of the image.

1	2
3	4

The above image has two rows and two columns, we will first zoom it row wise.

Row wise zooming:

When we zoom it row wise, we will just simple copy the rows pixels to its adjacent new cell.

Here how it would be done.

1	1	2	2
3	3	4	4

As you can that in the above matrix, each pixel is replicated twice in the rows.

Column size zooming:

The next step is to replicate each of the pixel column wise, that we will simply copy the column pixel to its adjacent new column or simply below it.

Here how it would be done.

1	1	2	2
1	1	2	2
3	3	4	4
3	3	4	4

New image size:

As it can be seen from the above example, that an original image of 2 rows and 2 columns has been converted into 4 rows and 4 columns after zooming. That means the new image has a dimensions of

(Original image rows * zooming factor, Original Image cols * zooming factor)

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.

Method 2: Zero order hold

Introduction

Zero order hold method is another method of zooming. It is also known as zoom twice. Because it can only zoom twice. We will see in the below example that why it does that.

Working

In zero order hold method, we pick two adjacent elements from the rows respectively and then we add them and divide the result by two, and place their result in between those two elements. We first do this row wise and then we do this column wise.

For example

Lets take an image of the dimensions of 2 rows and 2 columns and zoom it twice using zero order hold.

1	2
3	4

First we will zoom it row wise and then column wise.

Row wise zooming

1	1	2
3	3	4

As we take the first two numbers : (2 + 1) = 3 and then we divide it by 2, we get 1.5 which is approximated to 1. The same method is applied in the row 2.

Column wise zooming

1	1	2
2	2	3
3	3	4

We take two adjacent column pixel values which are 1 and 3. We add them and got 4. 4 is then divided by 2 and we get 2 which is placed in between them. The same method is applied in all the columns.

New image size

As you can see that the dimensions of the new image are 3 x 3 where the original image dimensions are 2 x 2. So it means that the dimensions of the new image are based on the following formula

(2(number of rows) minus 1) X (2(number of columns) minus 1)

Advantages and disadvantage.

One of the advantage of this zooming technique , that it does not create as blurry picture as compare to the nearest neighbor interpolation method. But it also has a disadvantage that it can only run on the power of 2. It can be demonstrated here.

Reason behind twice zooming:

Consider the above image of 2 rows and 2 columns. If we have to zoom it 6 times, using zero order hold method , we can not do it. As the formula shows us this.

It could only zoom in the power of 2 2,4,8,16,32 and so on.

Even if you try to zoom it, you can not. Because at first when you will zoom it two times, and the result would be same as shown in the column wise zooming with dimensions equal to 3x3. Then you will zoom it again and you will get dimensions equal to 5 x 5. Now if you will do it again, you will get dimensions equal to 9 x 9.

Whereas according to the formula of yours the answer should be 11x11. As (6(2) minus 1) X (6(2) minus 1) gives 11 x 11.

Method 3: K-Times zooming

Introduction:

K times is the third zooming method we are going to discuss. It is one of the most perfect zooming algorithm discussed so far. It caters the challenges of both twice zooming and pixel replication. K in this zooming algorithm stands for zooming factor.

Working:

It works like this way.

First of all, you have to take two adjacent pixels as you did in the zooming twice. Then you have to subtract the smaller from the greater one. We call this output (OP).

Divide the output(OP) with the zooming factor(K). Now you have to add the result to the smaller value and put the result in between those two values.

Add the value OP again to the value you just put and place it again next to the previous putted value. You have to do it till you place k-1 values in it.

Repeat the same step for all the rows and the columns , and you get a zoomed images.

For example:

Suppose you have an image of 2 rows and 3 columns, which is given below. And you have to zoom it thrice or three times.

15	30	15
30	15	30

K in this case is 3. K = 3.

The number of values that should be inserted is k-1 = 3-1 = 2.

Row wise zooming

Take the first two adjacent pixels. Which are 15 and 30.

Subtract 15 from 30. 30-15 = 15.

Divide 15 by k. 15/k = 15/3 = 5. We call it OP.(where op is just a name)

Add OP to lower number. 15 + OP = 15 + 5 = 20.

Add OP to 20 again. 20 + OP = 20 + 5 = 25.

We do that 2 times because we have to insert k-1 values.

Now repeat this step for the next two adjacent pixels. It is shown in the first table.

After inserting the values, you have to sort the inserted values in ascending order, so there remains a symmetry between them.

It is shown in the second table

Table 1.

15	20	25	30	20	25	15
30	20	25	15	20	25	30

Column wise zooming

The same procedure has to be performed column wise. The procedure include taking the two adjacent pixel values, and then subtracting the smaller from the bigger one. Then after that, you have to divide it by k. Store the result as OP. Add OP to smaller one, and then again add OP to the value that comes in first addition of OP. Insert the new values.

Here what you got after all that.

15	20	25	30	25	20	15
20	21	21	25	21	21	20
25	22	22	20	22	22	25
30	25	20	15	20	25	30

New image size

The best way to calculate the formula for the dimensions of a new image is to compare the dimensions of the original image and the final image. The dimensions of the original image were 2 X 3. And the dimensions of the new image are 4 x 7.

The formula thus is:

(K (number of rows minus 1) + 1) X (K (number of cols minus 1) + 1)

Advantages and disadvantages

The one of the clear advantage that k time zooming algorithm has that it is able to compute zoom of any factor which was the power of pixel replication algorithm , also it gives improved result (less blurry) which was the power of zero order hold method. So hence It comprises the power of the two algorithms.

The only difficulty this algorithm has that it has to be sort in the end, which is an additional step, and thus increases the cost of computation.

Spatial resolution

Spatial resolution states that the clarity of an image cannot be determined by the pixel resolution. The number of pixels in an image does not matter.

Spatial resolution can be defined as the

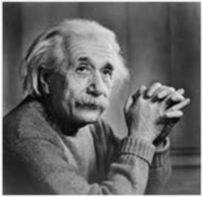
smallest discernible detail in an image. (Digital Image Processing - Gonzalez, Woods - 2nd Edition)

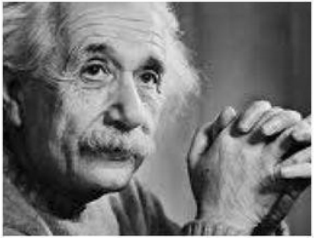
Or in other way we can define spatial resolution as the number of independent pixels values per inch.

In short what spatial resolution refers to is that we cannot compare two different types of images to see that which one is clear or which one is not. If we have to compare the two images, to see which one is more clear or which has more spatial resolution, we have to compare two images of the same size.

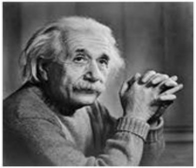
For example:

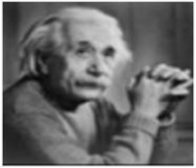
You cannot compare these two images to see the clarity of the image.





So in order to measure spatial resolution , the pictures below would server the purpose.





Gray level resolution

Gray level resolution refers to the predictable or deterministic change in the shades or levels of gray in an image.

In short gray level resolution is equal to the number of bits per pixel.

We have already discussed bits per pixel in our tutorial of bits per pixel and image storage requirements. We will define bpp here briefly.

BPP

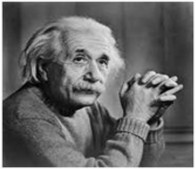
The number of different colors in an image is depends on the depth of color or bits per pixel.

Mathematically

The mathematical relation that can be established between gray level resolution and bits per pixel can be given as.

$$L = 2^k$$

For example:



The above image of Einstein is an gray scale image. Means it is an image with 8 bits per pixel or 8bpp.

Now if were to calculate the gray level resolution, here how we gonna do it.

$$L = 2^k$$

Where k = 8

$$L = 2^8$$

$$L = 256.$$

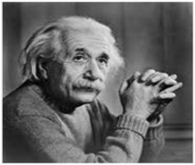
Reducing the gray level

Now we will reduce the gray levels of the image to see the effect on the image.

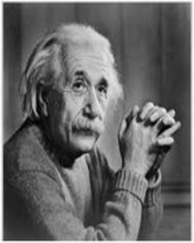
For example

Lets say you have an image of 8bpp, that has 256 different levels. It is a grayscale image and the image looks something like this.

256 Gray Levels

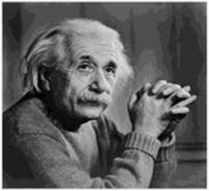


128 Gray Levels



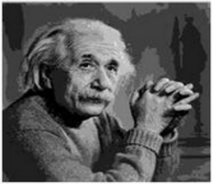
There is not much effect on an image after decrease the gray levels to its half. Lets decrease some more.

16 Gray Levels



Boom here, we go, the image finally reveals, that it is effected by the levels.

8 Gray Levels



Contouring

There is an interesting observation here, that as we reduce the number of gray levels, there is a special type of effect start appearing in the image, which can be seen clear in 16 gray level picture. This effect is known as Contouring.