Biometrics

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Lecture No. # 03

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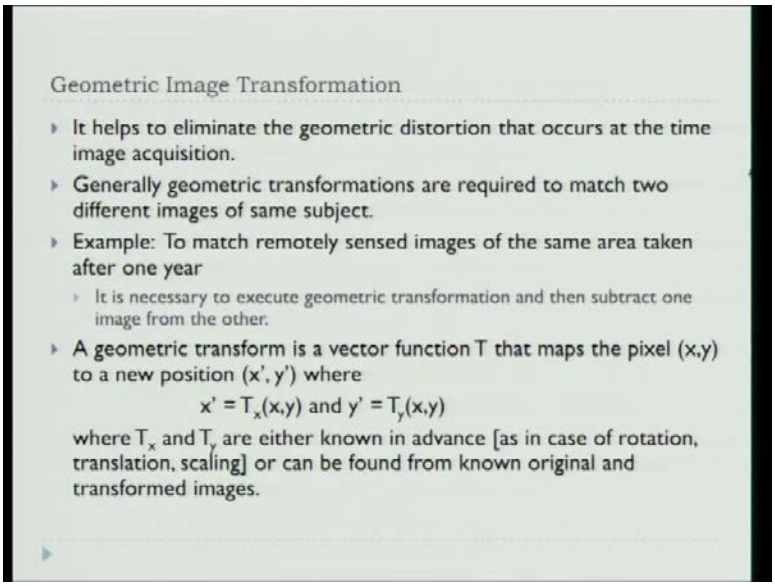

Since the last class, we were discussing about that geometric image transformation. And I will first browse little from the last class, so that you know, you can recollect, what I was discussing. That geometric image transformation is required because of there are certain distortion, you will find in your image. Now, distortion may occur due to several reasons. One is may be the distance between the subject or object and the camera may not be fixed, because why I need? I need to compare the 2 image or I need to understand the correct picture, I want to see the correct picture. So, in the case of say satellite image, I need to correct it, because of earth is rotating earth curvature is there. So, those corrections I need to make it.

So, that you can visualize the thing, same is the case with the biometrics also once I take the picture, I mean 2 pictures I need to compare. So, I need to know whether the photographs are taken from the same distance or not, if not then I need to do little modifications. So, that it looks like that it is similar it is at the same distance. And beside

that there are other types of distortions are there. Say for example, that sensor is not performing well. What is the guarantee? That some of the suppose I have the several CCD lights to capture your data, and you cannot imagine the or cannot think that intensity of each sensor or each CCD is same this some you know, some if you have the several tube lights, some of the tube lights that is not giving full illuminated thing illuminations, some of giving the due illuminations.

So, the area which you have the affected area, you need to do certain operations to get it equivalent illuminated area. Same is the case with the there may be some noise or there may be some CCD lights are not giving the it is not working at all. So, you need to do certain corrections on it. So, generally this transformation is required to match the two images you have obtained after two times, different timing stands. Because if it is a same instance, same type same distance everything is same what to do what for you are comparing you got the image.

Now, that transformation is nothing, but that you want to have that x y. You know image is represent by x y coordinate system. So, you want to impose some transformation as x y to get the new coordinate system, which is x dash and y dash. Now, this transformation factor is dependent on two things. First one that is may be like that that you know apriority, the distance. The distance between subject and the camera is one meter and another one is three meters. That is known to you or you know apriority that it is rotated by theta degree or you know that because of some you know that knowledge is given to.

Another one is that now I have the two image. As in the case of biometric side two image I need to compare. And another that I now applied two image and solve this two image I want to super impose. So, that you can compare so this is that the for a given image suppose, this is your original image and this is another image you want to compare. So, you need to do some operation to map in such a way that it is becomes the comparable. So, these two information are given to you this two images are given to you to, convert one into another one.

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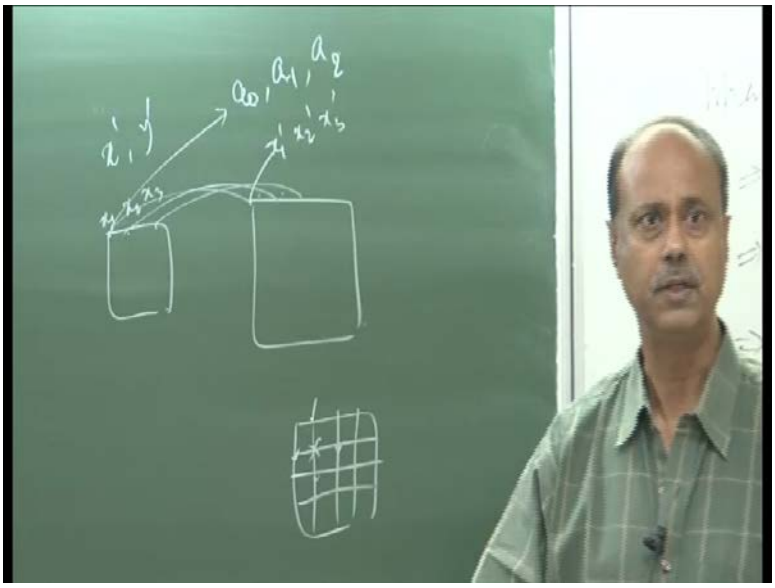

Now, generally it is assume or you or it is also, you can think that it is acceptable to you. Also, that whatever transformation matrix you are using or vector you are using function you are using that is will be true for throughout the image. Suppose, I am rotating with this point by theta degree the next will also be rotating by theta degree. So, that is whatever operation you will be or whatever, transformation you are looking for some pixels that should be true for all other pixels. Second is that generally it is assume. That distortion is within few neighboring pixels. For a particular pixel distances should not be a very difficult or very complicated one.

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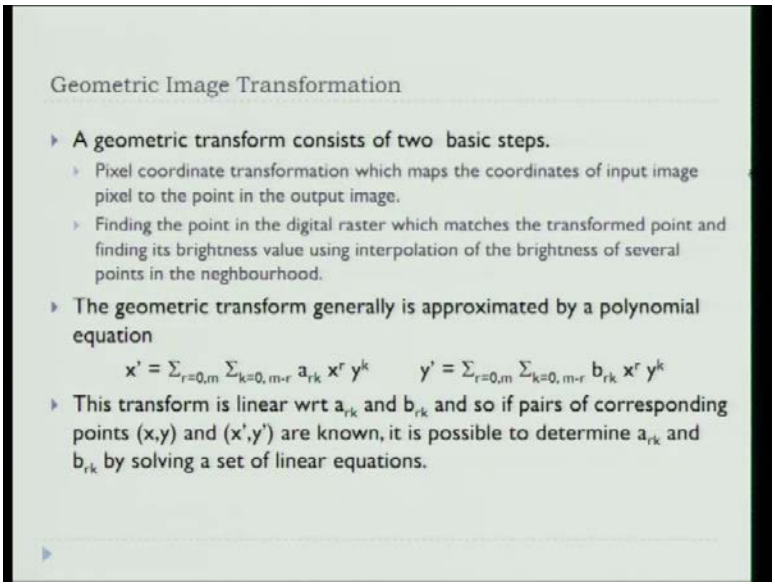

So, generally we assume that it is of the type polynomial of degree n. But this polynomial of degree n we assure that not more than three. Because you can think of degree k, but problem is that as you are increasing the degree k. You have to estimate k plus one coefficient for x dash and k plus one coefficient for b dash or y dash. So, more complex work by the more time you are implement you are considering. So, generally it is sufficient where we feel that degree two or degree three is sufficient. Now, once I consider the degree two or degree three. Degree two means, basically I need the six, three for x a 0 a 1 a 2 and three for y that is b 0 b 1 b 2. So, you need to obtain that x dash and y dash for x, simple to degree to you need the a 0 you need to compute this one.

That means, you need one variable here x 1 x 2 and x 3 agreed, to get corresponding x 1 dash x 2 dash and x 3 dash. If I note these three values I can compute these values by d, square fit in yes or no. So, that is along the x along the x directions similarly, is the case with the y directions. If I need to compute of degree two polynomial and x direction and y directions separately then I need that another three pairs with respect to y, b 0 b 1 b 2 then you can compute. Now, you remember what I am doing here that I am considering x 1 x 1 dash x 2. Corresponding value is y 2 dashes and x 2 dash and x 3 corresponding value is x 3 dash to compute a 2 a 0 a 1 a 2.

Now, the grid if I consider this as a grid, you remember that these value is not only dependent on this one this one it should be dependent, on this one and this one also. Because it is not guaranteed that x is it x and y are independent, the impact may be there. So, there another way is that you can think about the bilinear interpolation, bilinear values or bilinear transformation. So, it is a 0 a 1 x a 2 y plus a 1 a 3 x 1. So, here it is a four value constants a 0 a 1 a 2 a 3 and b 0 b 1 b 2 b 3 for y. So, corresponding you need four such equations. So, basically four 4 x 1values and x 1and four y values you need to estimate x dash and y dash. So, that is why it is four pairs of corresponding value c.

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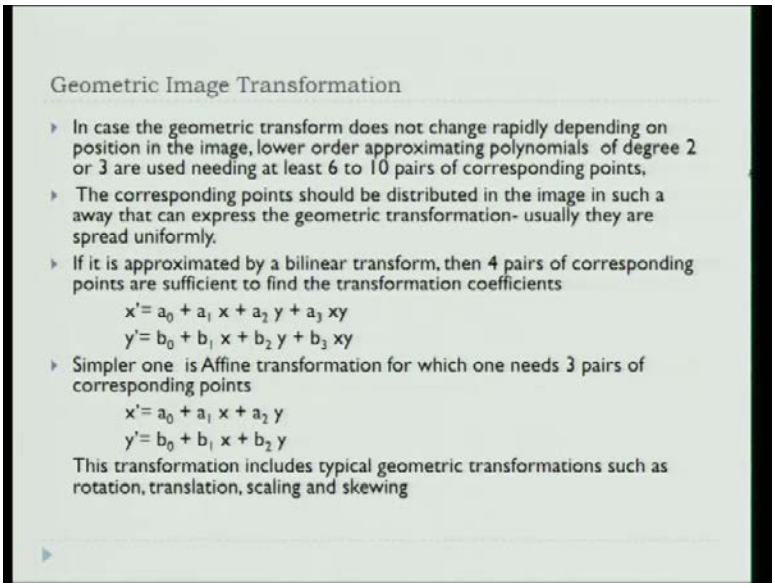

Now, similarly, is the formation where it is a only you are considering the a 0 a 1 a 2 a 0 a 1 x plus a 2 y because this is only it is considering. So, to estimate this you are taking only this values this value and this. So, that is the thing it is considering that only linear thing nothing simple equation not the interrelations between x and y and. So, on and this is takes this takes the rotation translation and scaling and skewing. What is rotation? That it is if I want to rotate the imager by theta degree. What is translation? That I want to move the because you know the photograph may be this one and the same photograph may be little up.

So, need to move up. So, that that is translation. What is scaling? That I want to zoom it zoom out and saw. And finally, skewing means? I need to slant the image by theta degree. I were this is I want to slant it by theta degree nothing else. Now, this also I told that it is creating geometric transformation creates, a new system or new coordinate system. And Jacobean gives you the information about how that coordinates system change changes.

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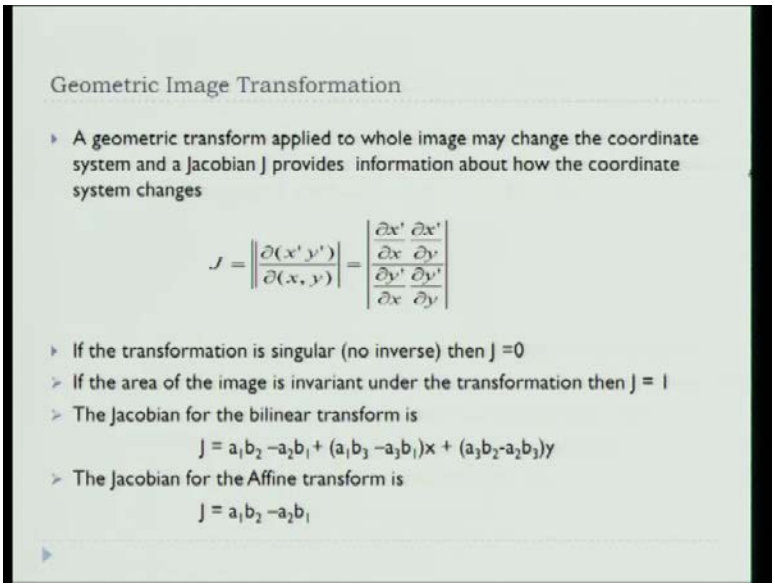

So, it is nothing, but the derivative j whatever transformation function you are taking you are derivative with respect to x and with respect to y. Partial derivative and then you take the determinant of that. So, if the transformation is singular that is no inverse nothing is then j will get 0. And if j is equals to one that means, that this whatever, system or transformation you are. Whatever system you are making that area what the images invariant under that transformation. So, I want that it is rotation in an invariant; that means, j must be one, it is invariant to scaling that j must be one that is the idea.

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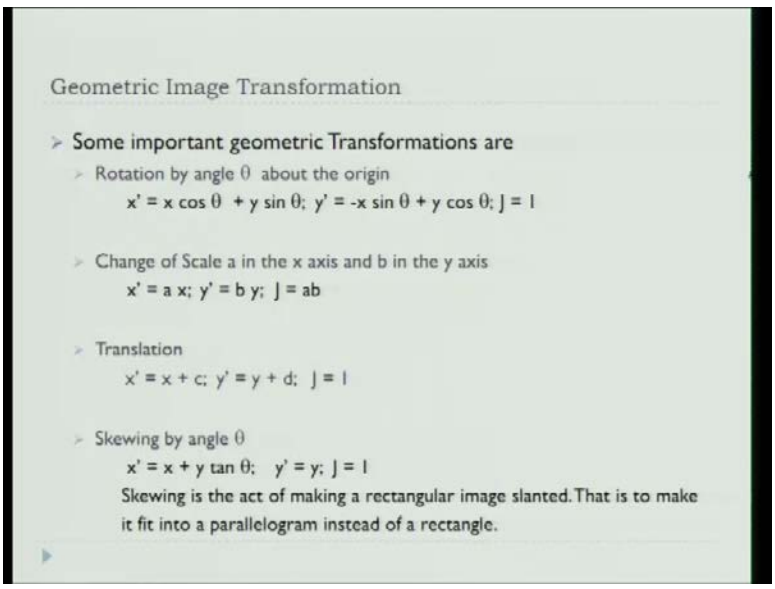

Now, bilinear j value will becoming like this, and for transformation that j value will becoming that a 1 b 2 minus a 2 b one. So, this is a standard the formula of rotation. That I want to convert polar two Cartesian say if same idea here and j is if you take the derivative of here is this and j we will find one for the scale it is also a b and. So, it you cannot tell it is invariant to a to this perfectly because it is dependent on the value of a and b and translation and skewing by theta degree angle.

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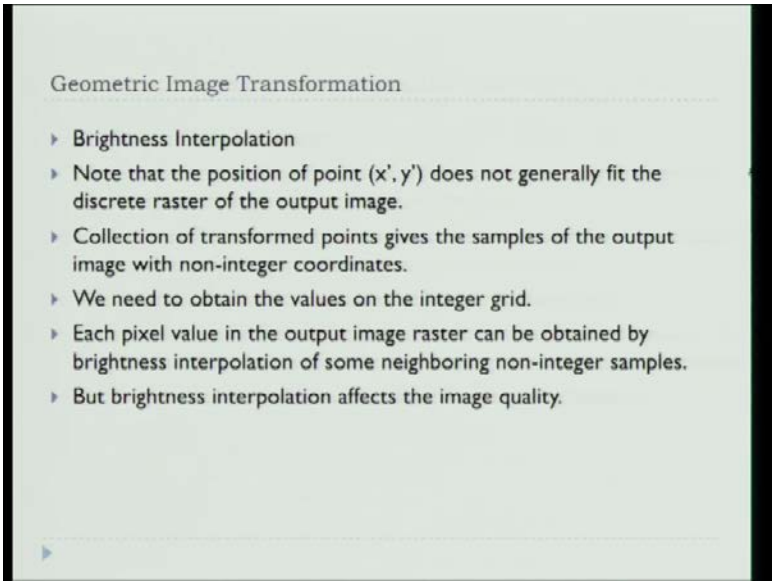

Now, what happens that you got from one coordinate system to another coordinate system this is the first step. Now, once you got the new coordinate system you have to put the intensity value on that coordinate system. So, that brightness to be interpolated. So, what happens I have this intensity value and I have and I got the new coordinate system for this value I got x dash and y dash. For this x y you got x dash and y dash for this x y this is integer, but this is not guaranteed and this will be integer this will be a real. Because you have obtained say in the case of in the case of rotation, it was x cos theta plus y sin theta, something like that you will get some real number. So, for this real number what is the intensity value you have to find now? And this is true for the whole image that is the problem.

So, so as I am telling that it is not necessarily that will be on the integer platform the values will be coordinating that into non integer. So, you need to obtain the values of the integer. Because your output image is also grid and you got the value of x dash y dash

here. But this is not useful to b I need to know the intensity value for this elements. I need to get the intensity value for this integer values not this intermediate ones. And this interpolation whatever interpolation because you will be taking the help of the neighboring ones to determine the intensity value. So, value of each coordinate points.

So, this interpolation technique should be you know very useful. Because very powerful thing that you should consider such an interpolation formula. So, that the quality maintains. Now, if you take this very simple interpolation formula. The quality will be degraded, but if you take the very complicated one Lagranges interpolation formula. (( )) You will get the very good quality image, but the complexity will be increasing. So, there exist a trade of relationship between the quality and the complexional time.

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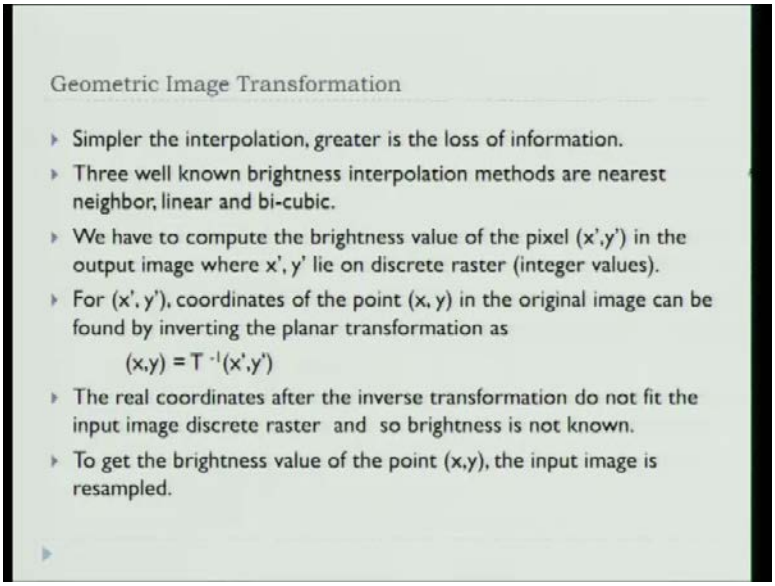

So, simpler is the interpolation formula, you are losing the information more. The three well known if brightness, interpolation or intensive interpolation technique they are, one is the nearest neighbor next one is the linear and third one is the bi-cubic. Now, as you know that you have to compute the intensity value of the output image from the input image. Now, you got a transformation matrix or the vector through which you got the x dash y dash unfortunately, they are in real domain. So, you obtaining the intensity value for the output image will be little difficult if I follow that path. Instead of doing that I get this is my output image, for each coordinate if the input image what is my x dash and y dash I can I find out just inverse transformation.

I know now a 0 a 1 a 2 a 3 whatever, coefficients of the equations. Now, if I know a is your a one. So, I have x dash equals to a 0 plus a 1 x plus a 2 y plus a 3 x y, I know these values. So, I know also x dash and y dash x dash and y dash I can obtain what is the value of x in my original input image yes. So, that will be in the real domain. So, if I know the intensity value of that real domain I can find out what is the intensity value of that yes or no agreed. So, I have if my input of original this is output one this is input one output this one suppose, this match to this one. I have to estimate the intensity of value of this which can mapped here agreed. Now, how to do this that is the problem now.

Now, the problem is simpler problem what is the problem? Problem is that I have an input image and I am here this has come from some grid of output image; from this one has been mapped here. Now, I have to estimate the intensity value of this which can be put here. And that is the three ways with what we like to make one is nearest neighbor another one is linear and third one is the bi-cubic. So, this is to get the value of the by the value of the point, the input image is resample this is known as resembling.

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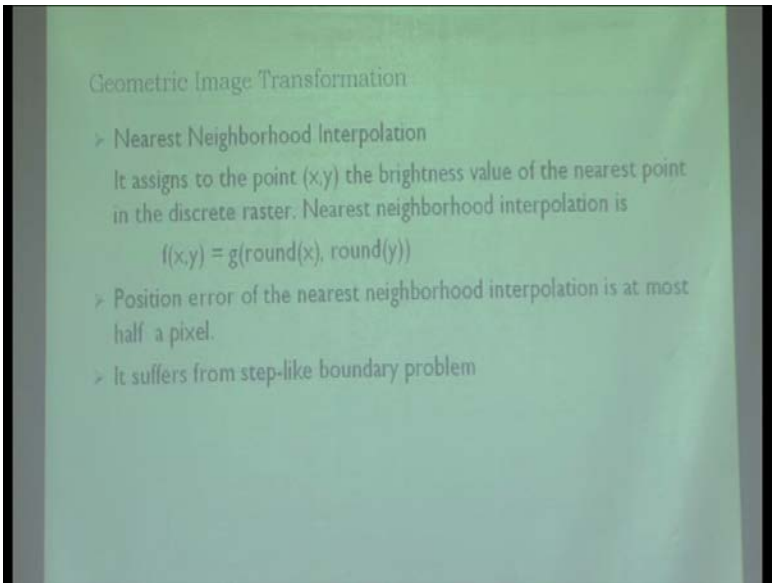

Now, in the case of nearest neighbor, idea is very simple say I have x dash here and I have y dash. I take the round of x dash I take round of y dash suppose this is capital x and this is capital y.

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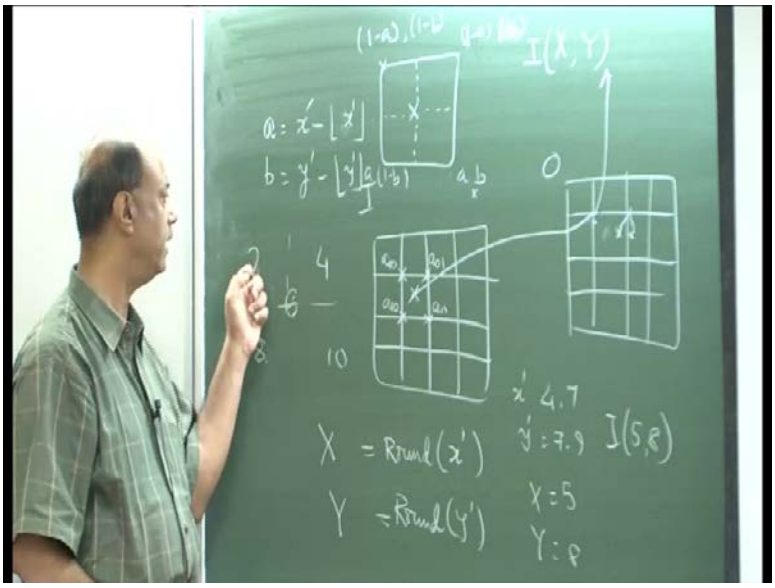

So, I can put the this intensity value is nothing, but I of input image this is output image I of capital x capital y. Round of x dash suppose it is 4.7 and x dash is 4.7 and y dash is 7.9. So, round x is 5 and y is 8. So, I find out what is the intensity value of I 5 8 that I will be putting here is it clear. So, how much error I am making a half pixel not more than that it was 3.5 and I have made it 4. If it was 4.5 and another side I have made it 5. So, maximum error is half pixel. But in reality suppose, a pixel is represent one meter by one meter then basically error will be 0.5 meter cos 5 5 5 meter 0.5 meter in x direction 0.5 meter in y direction.

That is error, but method is very simple. But it creates little problem that is since you are making it the nearest neighbor approach. You are not there is a chance there is a chance that stepwise, step like boundary problem will be there. Because why step length because this will be map to this and there may this suppose this is this is map to this and this one also will map to this. So, one is positive 5 pixel another one is negative 0.5 pixel shift to this. So, there is a there is a chance of like this movement error will be there. So, error is point 5 pixels in x direction and y direction and there is a possibility of shape like boundary problems. This is the only because of taking the boundary factor.

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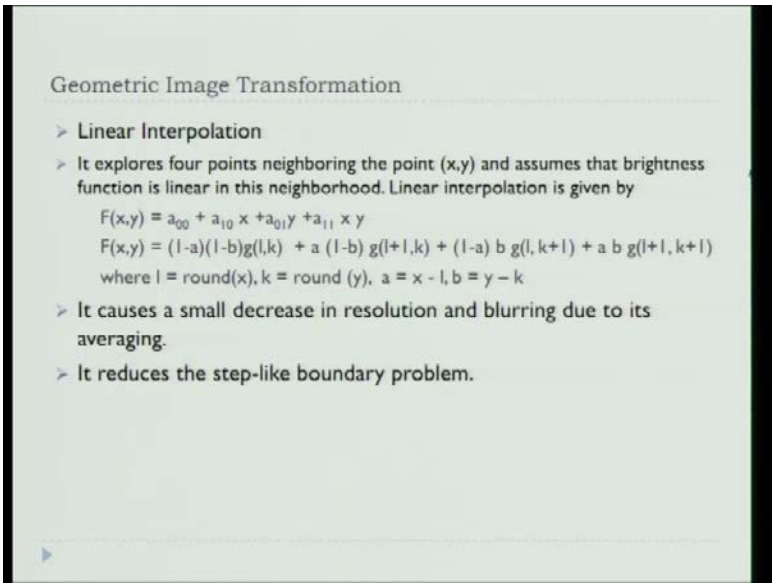

Now, the second one is that linear interpolation which is more powerful than the nearest one. Because here he is not only considering he is not only considering the this, here round of this one he is considering this 4 pixels information. This four pixel information and he wants to give the weight age on all this four elements. So, let us assume this is a 0 0 this is known as a 0 1 this is a 1 0 and this is a 1 1. These are the four coefficients. I am writing a 0 0 plus a 1 0 x plus a 0 one y plus a 1 one x y r. So, this if I start thinking little different way then what happens? This is your points to be estimated and say let us assume this is a, is x minus x dash x is minus that and b is y dash minus y dash.

So, integer so I get the leftover part that if I x dash minus x bar is what that whatever 0.5 0.3 0.7 that number will be coming. Similar, y dash minus the lower in lowest integer largest integer smaller than, y dash so you get b. So, I give the weight age on this elements as 1 minus a and 1 minus b here it is 1 minus a, and b and so on. Similarly, here a 1 minus b and here it is a b. So, that is the thing some weight I am giving because I have to give the weight to each. So, depending upon the distance from the coordinate system we are putting that weight. So, this is nothing, but 1 minus a 1 minus b and intensity value of this one into here I have written a, and here it is 1 minus b, or no it was correct.

Then a, into 1 minus b intensity value of this plus this into intensity value of this and also same way you have written this. So, this is very simple just you put it and you will be

getting the intensity value of this points, that will be mapped to my output image agreed is it clear. But in that process, since I am giving the weight ages all the four neighbors all the four neighbors. So, that stepwise boundary effect will be minimum it will it need not be 0, but it will be as minimum as possible. So, but at the same time suppose I use a, equals to half and b is equals to half that will be exactly centered that is nothing. But that averaging of the 4.4 intensive value and you are putting it.

If a, equals to half b equals to half then it is nothing, but the four points intensity value and you are averaging it and you put it. Now, once I am giving the average of the phone numbers, what will happen the resolution will come down yes or no. Suppose I have any phone numbers you take 3 say this is 4 and this is say 8 and this is 10 and for simplicity if this is 6. What is the value? 6 and 18 is 24. So, this will be what divided by 4 6. So, the number that for this points it is 6 it will come to the I am telling that this is half. So, this will become 6.

Now, the resolution say it may be it should have been the 10 or should have been the near to 2 and 4. But because of this that intense resolution will come down because you are making nearly averaging technique, and once resolution comes down. So, what will happen to my output image? That resolution would be come down will be coming down overall or each point is resolution will be down. So, it will be having little dull image agreed. Now, what is the dull image and so, image is dull this it will be blurring effect. But image will be smooth there is no ambiguity image will be smooth looking smooth, but it is a dull image and blurring effect will be there. But of course, the step like boundary problem will be minimize.

So, what I did here I have taken the 4 neighboring points to estimate the intensive value of x dash and y dash. Now, what happens to the bi-cubic technique? The bi-cubic technique you have the you are considered for this point. I will be considering this point this point this point this points (No audio from 27:21 to 27:27) this sixteen points. This sixteen points and same idea we have used for bi-cubic also that I have given a 0 this weights corresponding weights and that you get the weight. Now, obviously, since linear interpolation is reducing the step like boundary problems the cubic equation it also, obviously, it will be reducing further there is no ambiguity.

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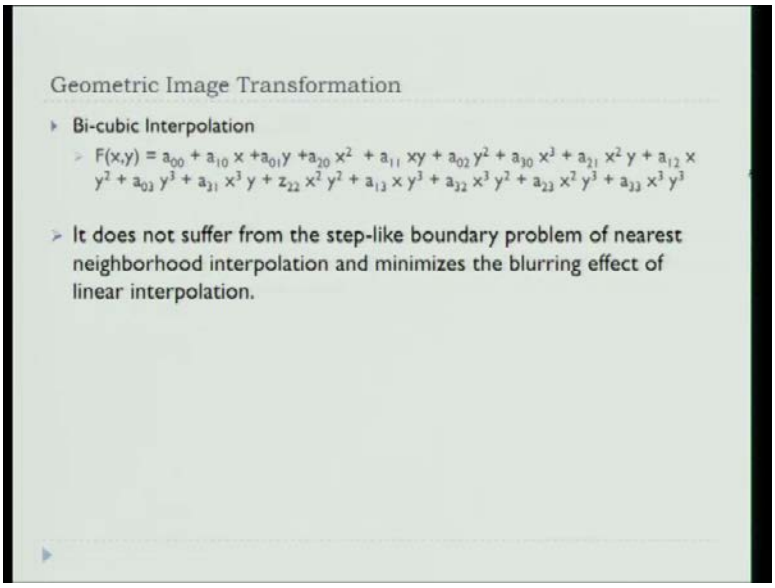

Now, the blurring effect on the linear interpolation because of only four points you are taking it was making the dull. Now, suppose let us consider another example 3 4 5 6 3 3 4 5 6 7 8 some number. (No audio from 28:34 to 28:44) So, this is the point is there now, if you obtain suppose let us assume that it is also I am not using the because I have to compute otherwise that let us assume that. I am just adding up and divided by sixty that is also average. But if you observe this average will be better than the (( )) more points. So, properties of more neighboring points you have taken into account. And you are trying to fit a degree you know by cubic degree cubic degree you are trying to fit on it.

So, obviously, you will be getting the much better intensity because you are taking the information of more number of neighboring points. So, if this is all about the geometric image transformation. What I have done here that given one image and you want to compare with another image you need to transform one of them, so that you can compare. So, first step is that you have to use some method to convert one coordinate system to another coordinate system. Once you have defined that coordinate system now, you have the one input coordinate system and another it is a output coordinate system. From the output coordinate system you try to map into the input coordinate system.

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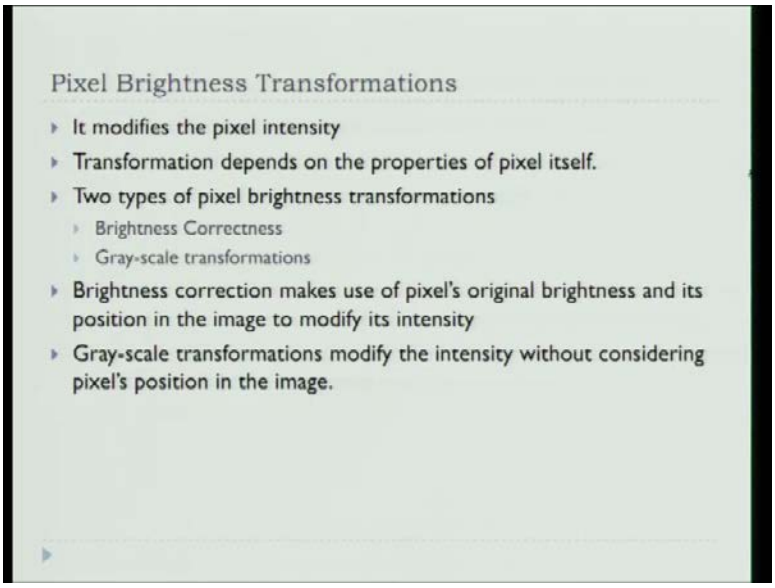

And use one of three methods to get the intensity value of the output coordinates systems, that is the strategy. This is what we have done that after transformation geometric transformation you are changing the intensity value. The another problem you will be finding that I have one image. But you need to do some operation for example, that you have launched one satellite. And you are suppose to get the intensity level 0 to 255 suppose, to get that is the plan, but unfortunately it is giving the data which is lying between say seventeen to thirty-two, intensive values are lying between seventeen to thirty-two.

Now, if seventeen that will not be much useful because you know it is a very poor quality image nobody will understand. So, what you have to do you need to improve the intensity to enlarge the intensity. So, that people can visualize it is lying between zero to fifty-five. So, there this no question of geometric transformation is it a question of radiometric corrections that you need to do some corrections. So, that it looks better. So, it is pixel by pixel. So, it modifies the pixels intensity. So, it takes the help of that pixel only it does not consider the other pixels information. Now, the two types of pixel brightness transformation one is the brightness correction. As I told you that only I want to transform from one to another one nothing else.

Another one is the gray-scale transformation. Now, in the case of brightness transform corrections, it takes the pixel intensity into a account and also it takes the position of the

pixel. Why it happens? Why it is required? For as I told you that some of the all lights are not giving you the equally illumination things some of them you may find is not doing the things. So, what happens that for that area, you need to do some corrections. So, the position of the pixel is important not only that intensity of the pixel you want to improve. And you have to also find out the position of the pixel for that you want to improve it.

In the case of gray-scale transformation it modifies the pixels without understanding its position it is not required only it modifies the intensity. But it does not need to know the position of the pixel. So, ideal situation is what that whatever device you have. And through the device whatever, image you are getting that image should be should not be,

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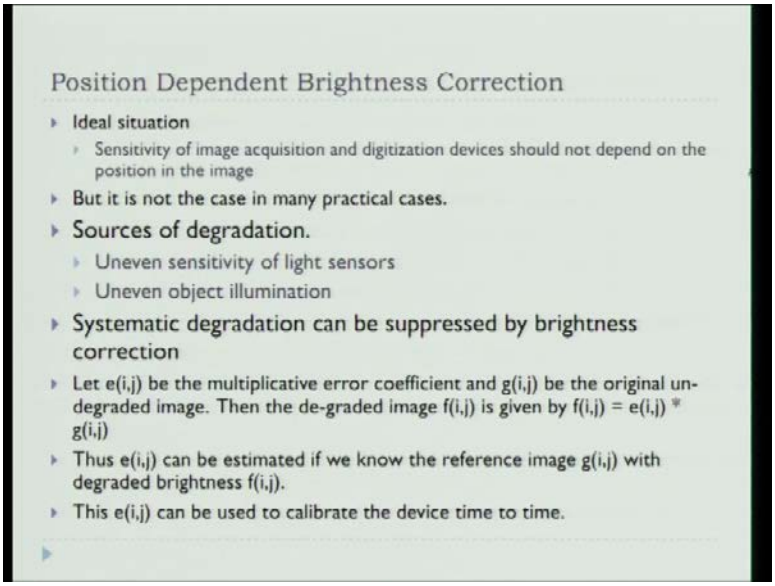

dependent on the position. That any pixel I will assume that that any pixel give me the good results that is the idle situation. But as I told you an example, that light sensors may create the problem for you. Another one is that illumination effect is also creates a problem.

Say for example, that background of the image is something different. So, neighboring area this area will be reflected more front area may not be reflected much. So, this systematic degration can be supplied by the brightness corrections. Suppose I know that e i j is the error, to be corrected with the, i j pixel. And I know that image g i j is the

original image that it should look like this i j pixel is g i j. And, but you are getting you are getting the image f i j i j element intensity f i j. So, f i j is the e i j into g i j.

Now, this e i j you have to estimate. So, you take one original picture and you take the output picture you can find out what is e i j. Once you know this e i j that has to be calibrated every time whenever, you take the photographs and, but you have to estimate. Because you know that light sensor also performing dig ration would be there continuously. So, calibration has to be done at a regular interval. So, e i j need not be fixed throughout your life span.

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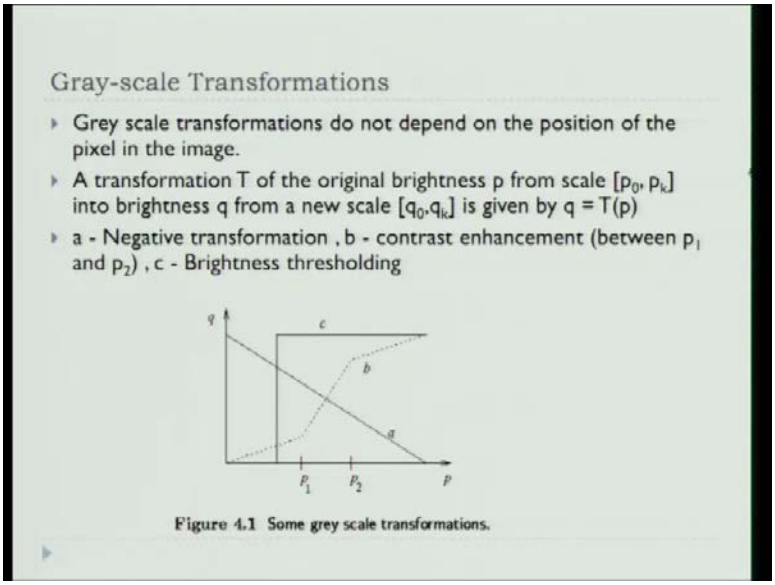

The other one is the gray-scale transformation as I told you that it is not dependent on the position of the pixel. But what happens sometime, I like to see the indication of my image what it means that whatever pixel value I have that white I want to convert into the black I want to convert into white. So, if I draw this graph that all the zero intensity value. I want to put the highest intensity value all high intensity value I want to put the low intensity value. So, for each pixels I change it change the intensity level by some method. And that is that can be done using the simple look up table that 0 max to 2 55 1, max to 254, 2 max to 253. So, as soon as I get a 1 intensity value I just replace it by a look up table agreed.

Similarly, is the case that I want that this intensity area I want to make it zero. I do not want I do not want to make it dark and remaining I want to make it white. So, all the

pixel values all the pixel intrinsic value more than this they are all white. And the I can put the and then I he pixel will be getting my intensity chart is like that or I sometimes what I want that all the pixel having the intensity value lying between p 1 and p 2. I want to put this curve up otherwise I want to put this way it is possible.

So, this will be depending on the situation sometimes, I like to give the importance only on the snow area. You got a photograph where snow is there I want to give the importance on the snow area. So, the snow may not be always white sometimes, you may get because of sunlight you may get the yellowish color. So, you need to convert them also into the snow and you may. So, you will be able to make them 254 or 255 and you get the snow area. And other part I can suppress it I do not want to see I make it zero. So, simple look up table can be used to break this transformation.

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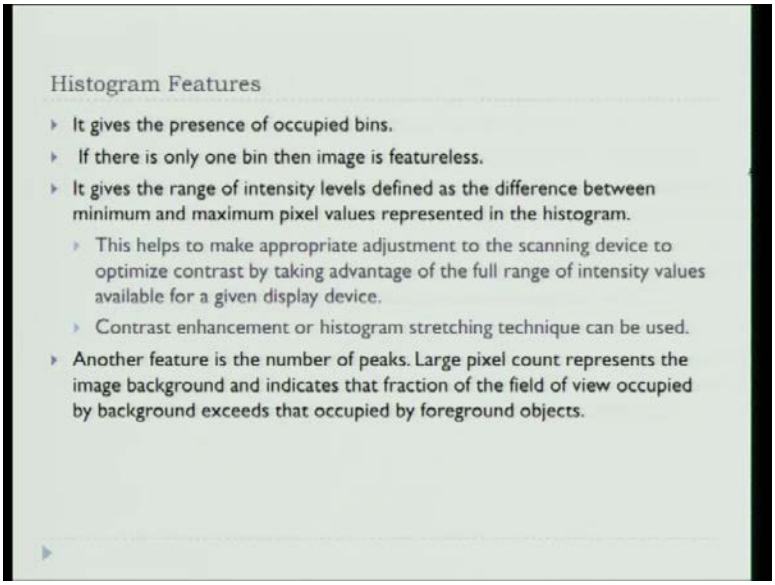

Now, next picture is histogram. Now, you know what is histogram? Histogram is gives you the information about frequency of occurrences agreed. So, same idea here you have the two dimensional image and the image contains the pixel values or intensity values of each pixel. This pixel values will be lying between the two minimum intensive levels and maximum intensive level idle case it is 0 to 255. But in reality it will be lying between say some numbers p 1 and p 2. So, I can have (No audio from 38:55 to 39:07) the frequencies of the intensity value p 1 is this much then frequency of occurrence of intensity p 1 plus 1 is this much and so, on.

And that sum of this frequency is the total number of pixels agreed. So, I can have the histogram or from the image this histogram is very powerful. Suppose there is only one peak or only one level only one. That means, that all the elements in the image is having this value. So, no information will get from that image. So, you will be telling that it is a featureless image agreed. So, if there is only one bin then you tell that image is featureless, by seeing the image or histogram you can tell always. What is the intensity level or what is the maximum intensity and the minimum intensity of the image? Am I right because you will be doing this is the minimum intensity level and that this is the maximum intensity level.

So, range of the intensity level is known to you. And once you know the range of the intensity level, you will be able to think that whether there is a need to change the intensity level. Suppose I have a one image where intensity level is lying between fifty-five and seventy-five. And another image of the same object or subject is lying between say of fifteen to two hundred. So, you know to compare this to you will like to convert either fifteen to two hundred to that previous size intensive level of previous one to try it on. So, that it looks alike. So, in order to do that you need to perform one technique which is known as contrast enhancement technique or histogram stretching technique.

And now, if I want to put in some hided information on my image I cannot put the hidden information on my original image which is keeping say your photograph. And then there is a background then now, if I put some information on your photograph then you will feel that yes I have spoiled your photographs. So, the information is I like to put that I will always like to put it in the background. So, this people who work in the field of steganography. They have to analyze which area he wants to put the data. So, that the original data does not get destroyed original image should not be destroyed. Otherwise people does not like to see that image at the same time we want to save some information through this image.

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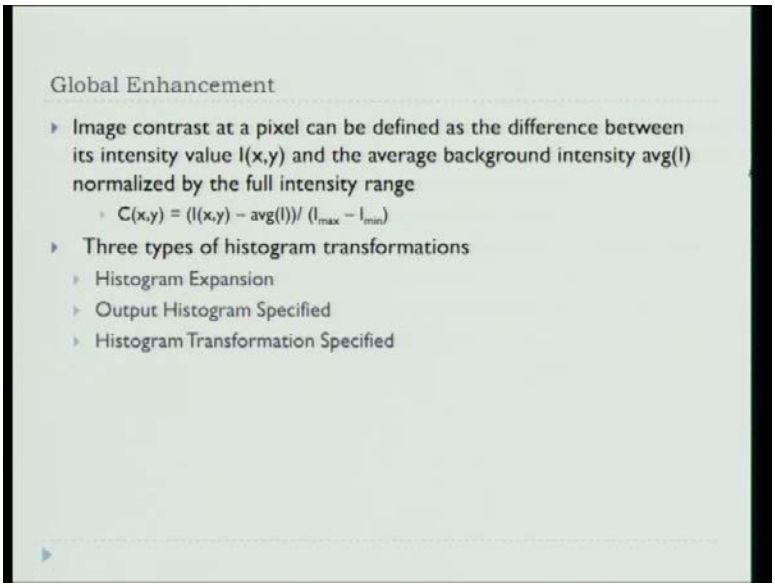

So, this background or information is very useful for several purposes, but not for not for. Now, we use the word contrast of an image. We tell what is the contrast? So, contrast of which depends on the contrast of the each pixel. So, what is a contrast of a pixel? Contrast of a pixel is nothing, but the image intensity at that pixel minus average intensity divided by the maximum intensity minus minimum. That is why I am dividing that is the normalizing the factor nothing, but that that. 1 minus 1 by I max minus I min now, this histogram we need to transform. As I told you that I have an intensity level line between a, and b I want to get to c to d how to do it.

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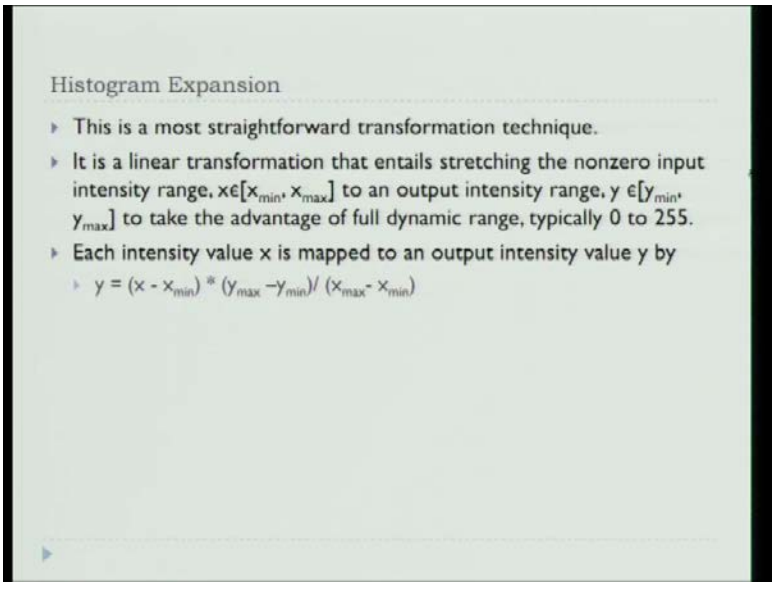

So, there are three ways you can do it one problem is Histogram Expansion this output histogram specified and finally, you have histogram transformation specified. What is histogram expansion? Is a very simplest one that I have one histogram lying between this range e 1 minus e 2 I want the histogram should not be this I want the histogram should be 0 to 255. So, this has to be expanded in that order. So, it becomes the range is lying between the minimum intensity level will be lying between minimum maximum line (( )) is it clear.

Why would we perform this?

Why we need.

Suppose I have an image whose intensity is lying between thirty-five and seventy-five. You can do I have the power to have this 0 to 255. So, 35 to 75 I have that image will be very dark color. And one is that even visibility right hand, but if I distribute it in the larger intensity level then you will be able to see the edges properly. You will be able to see the minor point which are missing in 0 to 35 to75. That may be visible for you image look wise will come out better way you can do certain operations like age detection properly and other things is it ok.

So, how to do it beam max is the best method to stretch linearly I will be stretching. That means, that means that the smaller p 1 value has been magnitude to 0 and p 2 has been magnitude to 255 agreed. So, how to I just I just a linearly I am stretching that linear stretching formula is simple linear equation x minus x 3 multiplied by y minus y mean divided by x max minus x min. It is a linear equation I am just putting to expand it.

Sir is this same as histogram stretching or contrast.

This is. So, what in the case of in the case of I want to expand it zero to two fifty five then y max becomes two fifty five and y min becomes zero.

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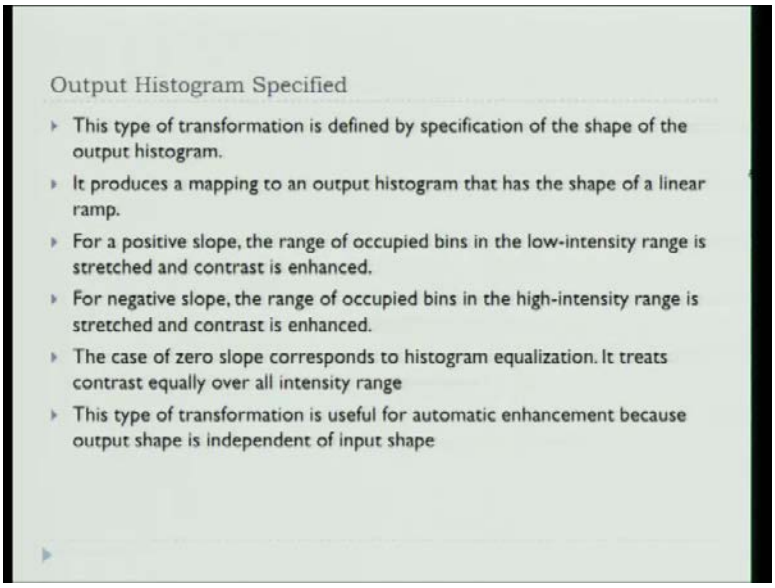

So, sometimes I may decide see the previous one can be done automatically. And if the input of the image I will automatically find out what is the minimum intensity level what is the maximum intensity level. And then automatically I can find out the stage one no intervention is required agreed. Now, here also output what should be the histogram of output that I want to do. So, sometimes I may not like to stretch it equally I want to give some importance to the lower intensity level not the higher one. Sometimes I want to give that importance to the higher intensity level not the lower one and so on.

So, for the positive slope the range occupied bins is the low-intensity level stretch. So, what should be the lower that depends upon your thinking or application that. I want to study the snow thing that the white higher intensity level only you want to discuss. If I want to see the dark area the lower intensity. And since I know acquiring the stretching level that is I want to stretch only. The lower intensity level. So, this also can be done automatically no manual intervention is required sometimes I do not know now this is useful to compare this to compare the 2 images.