Digital image processing.
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Lecture-55.
Full color image processing.

Hello, welcome to the video lecture series on digital image processing. In that we will discuss is full-color image processing uhh. And as we have said that unlike in case of pseudo color techniques, in case full-colored image processing what we will do is we will consider the actual colors present in the image. And as we have said that as there are different color models a color image can be specified in different color models, for example, a color image can be specified in rgb color space a color image can also be specified in hsi color space.

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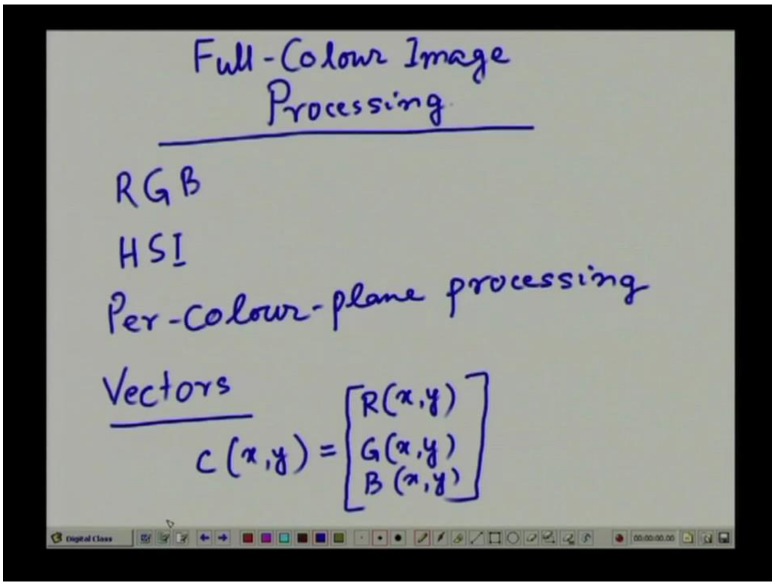

Now, because we have these different uhh color components of any particular color pixel. So, we can have two different categories of color image processing. One category of color image processing is per-color-plane processing. So, in case of this in this category what you do is? You process every individual color components of the color image and then these different processed components that you have you combine them together to give you the colored processed image and the other type of processing is by using the concept of vectors.

So, as we have said that every colored pixel has three color components. So, any color can be considered as a vector. So, if it is the color is specified in rgb space then it is a vector drawn to the point which it specifies the color from the origin of the rgb color space. So, there are two kinds of processing one is per-color-plane processing in which case every plane is processed independently and then the processed planes are combined together to give you the processed color output and the other type of processing, the other category of processing is when all the color components are processed together and there the colors, different colors are considered as vectors.

So, obviously the color at a particular point x, y c(x,y) if we are going for an rgb color space if it is specify the rgb color space the point x y will have three color components. One is the red color component at location x y, the other one is green component at location x y given by g(x, y), other one is blue component at location x y which is given by b(x, y). So, every color is represented by a vector and the processing is done by the considering these vectors, that means all the color components are considered together for processing purpose.

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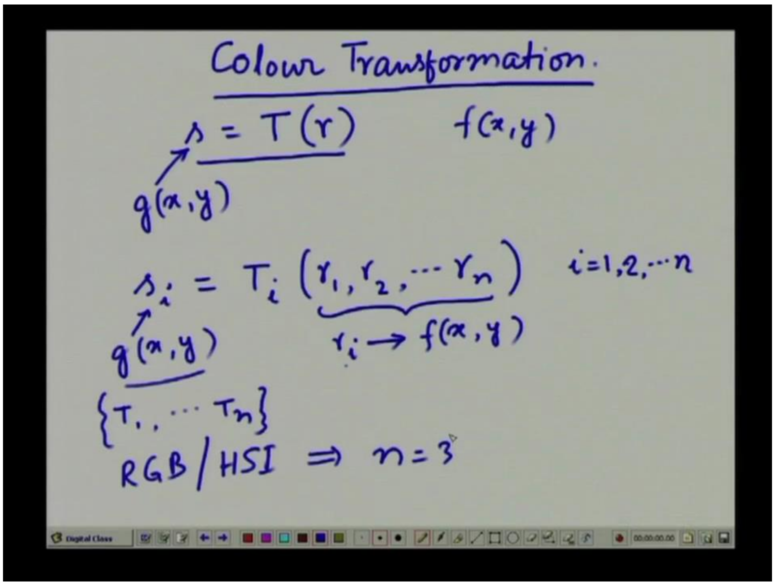

So, accordingly we will have uhh two types of color processing techniques. The first kind of processing that we will consider is what we called as color transformation. Now, you may recall from our discussion with the gray scale images or black and white images that where we have defined a number of transformations for enhancement purpose and there we have defined the transformations as say s is equal to some transformation t of r where r is an intensity value. Intensity at a location in the input image f(x, y) and s is the transformed intensity value in the corresponding location of the processed image g(x, y) and there the transformation function was given by s is equal to t(r).

Now, we can extend the same idea in our color processing techniques. The extension is like this now in case of intensity image we had only one component that is the intensity component. In case of color image we have more than one components that is may be rgb component if the color is specified in rgb space or hsi component if the color is specified in hsi space. Correspondingly we can extend the transformation in case of color as si is equal to some transformation function ti of r1, r2 up to rn for I equal to 1, 2,…up to n.

So, here we assume that the color every color is specified by a three component vector having values r1 to rn. Si is a color component in the processed image g(x, y). Okay and ri every ri is a color component in the processed image f(x, y). So, si is a color component in the processed image g(x, y) and ri is a color component in the input image in the input color image f(x, y) and here n is the number of components in this color specification and the ti that is t1 to tn it is actually the set of transformations or color mapping functions that operate on ri to produce si.

Now, if we are going for rgb color space or hsi color space then actually the value of n is equal to 3 because in all these cases we have three different components. Now, first application of this intensity transformation uhh of this color transformation that we will use is intensity modification. Now, as we can represent a color in different color models or different color spaces.

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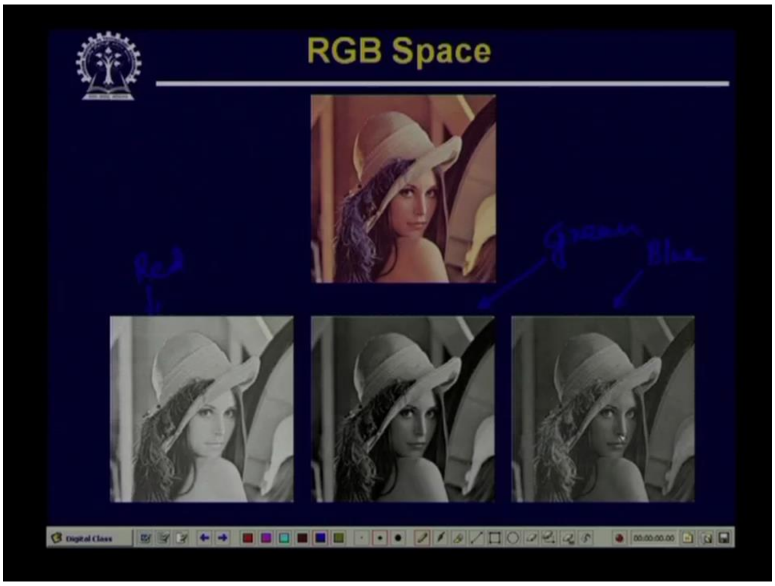

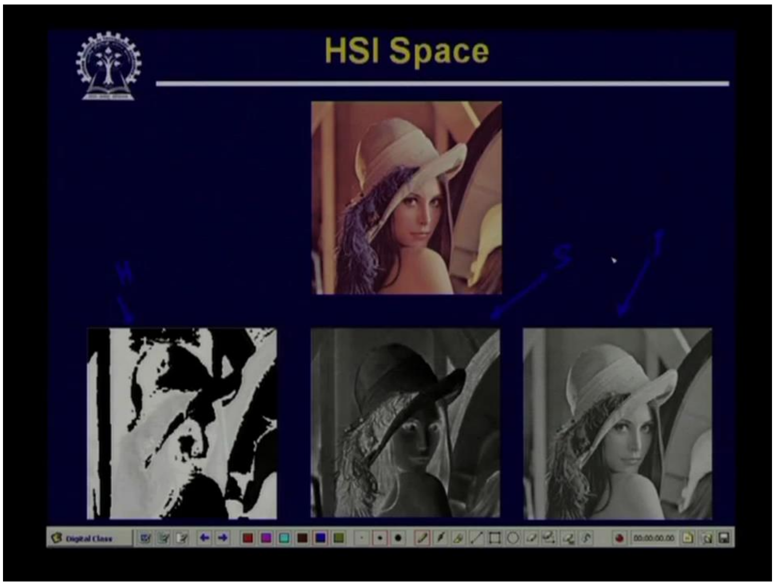

So, theoretically it is possible that every kind of color processing can be done in any of those color spaces or using any of this color models. However it is possible that a some processing some kind of operation is more convenient in some color space but it is less convenient in some other color space. However in such cases we have to uhh consider the cost of converting the colors from one color model to another color model. Say, for example, in this particular case you find that if I have a color image which is given in rgb color space the different color planes of the same image, this is the red color plane, this is the green color plane and this is the blue color plane.

So, this color image can have these different three different color planes in the rgb model. Similarly, the same image can also be represented in hsi color space where this leftmost image gives you the edge component, this gives the saturation component and this gives the intensity component. Now, from this figure it is quite apparent as we claimed earlier that it is the intensity component in the hsi model which is the uhh chromatic notion of brightness of an image.

So, here you find that this actually indicates what should be the corresponding black-n-white image for this color image. So, as we can represent a color image in this three different in this different model. So, it is possible theoretically possible that any kind of operation can be performed in any of these models.

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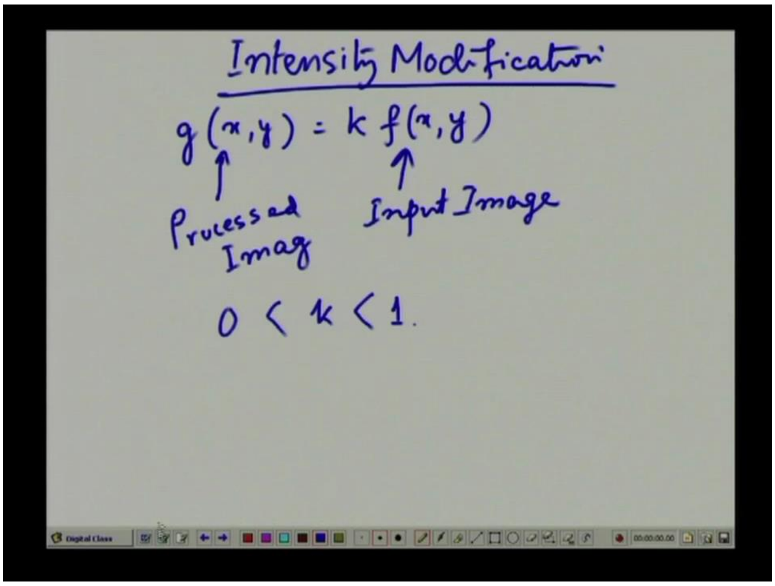

Now, as we said that the first uhh application that we are thinking of that we are talking about is intensity modification this intensity modification transformation is simply like this say g(x, y) is equal to some constant k times f(x, y) where f(x, y) is the input image this is the input image and g(x, y) is the processed image uhh and in this particular case if we are going for color scaling then our intensity intensity reduction the value of k lies between 0 and 1.

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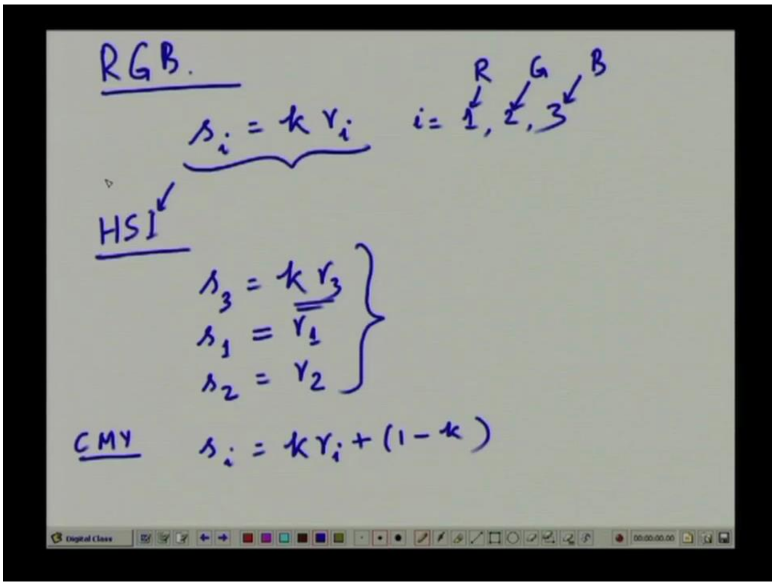

Now as we said this operation can be done in different color planes. So, if we consider the rgb color space then our transformation will be is si equal to the constant same constant k times ri for I varying from for uhh I is equal to 1, 2 and 3. Where one the index one will used to indicate the red component, index two is used to indicate the green component and index three is used to indicate blue component.

So, this indicates that all the different color planes the red plane, green plane and blue plane all of them are to be scaled by the same scale factor k, whereas if I do the same transformation in hsi space then as we said that the intensity information is contained only in i. So, the only transformation the transformation that will be needed in this particular case is s3 is equal to the constant k times r3 whereas the other two components corresponding to hue and saturation can remain the same.

So, we will have s1 equal to r1 that is hue of the processed image will then remain same as hue of the input image we have s2 equal to r2 that is uhh uhh saturation of the processed image will remain same as saturation of the input image, only the intensity component will be scaled by the scale factor k. The similar such operation if we perform in cmy space then equivalent operation in cmy space will be given by a uhh si is equal to the constant k times ri plus one minus k and this has to be done for all the I that is all the planes c m and y planes.

So, if I compare the operations that we have to do in rgb color plane uhh rgb space the operation in hsi spaceand the operation in cmy space you find that the operation in hsi space is the minimum of these three different spaces because here only the intensity value is to be scaled, hue and saturation value remains unchanged, whereas both in rgb and cmy space you have to scale all the three different planes. However as we said that though the operation the transformation takes minimum time in the hyspace.

the transformation has minimum complexity in hy space but uhh we also have to consider that what is the complexity of converting from rgb to hsi or from cmy to uhh hsi because back conversion also has to be taken into consideration.

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Now, if I apply this kind of transformation then the transformed image that we get is something like this. Here, the operation has been done in the hsi space, on the left hand side we have the input image and on the right hand side we have the intensity modified image.

So, this is the image for which the intensity has been modified by a scale factor of around 0.5. So, we find that both the saturation and hue they appear to be the same but only the intensity value in this particular case has been changed. Okay. Of course this equivalent operation can as we said can also be obtained in case of rgb plane as well as in cmy plane but there the transformation operation will be uhh will take more computation then the transformation operation in case of hsi plane where we have to scale only the intensity component keeping the other components intact .

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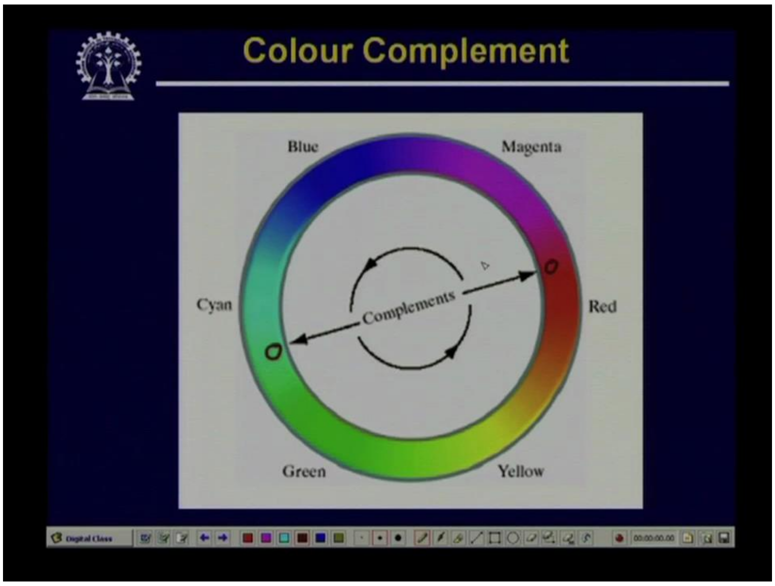

The next application of this full-color image processing that we will consider is color compliments. Now, to define this color compliments let us consider let us first look at uhh color circle. So, this is a color circle you find that in this particular color circle if I take the color at any point on the circle the color which is located at the diagonally opposite location in the circle is the compliment of the other color. Okay.

So, as shown in this figure that here if I take a color on this color circle its compliment is given by the color on this side and similarly, the reverse the color on this side has a compliment on the color on the other circle. So, this simply says that hues which are directly opposite to one another in the color circle they are compliments of each other.

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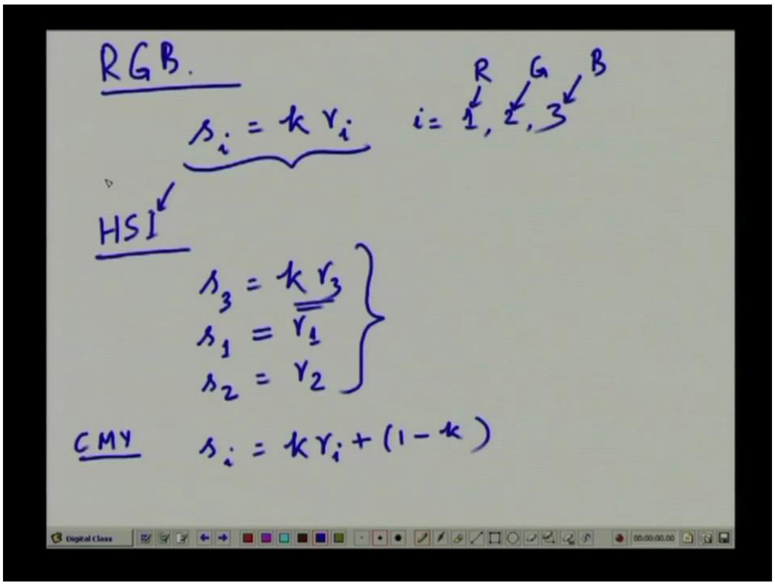

Now, this color compliment as we have said the color compliment this is analogous to the gray scale negatives. When we have talked about uhh the gray scale or intensity image processing, we have also talked about the negative operation.

This color compliment is analogous to that uhh gray scale negative operation. So, the same operation which we had used in case of gray scale image to obtain its negative if I apply the same transformation to all the r, g and b planes of a color image represented in rgb space then what I get is a compliment of the color image or this is true a really the negative of the color image.

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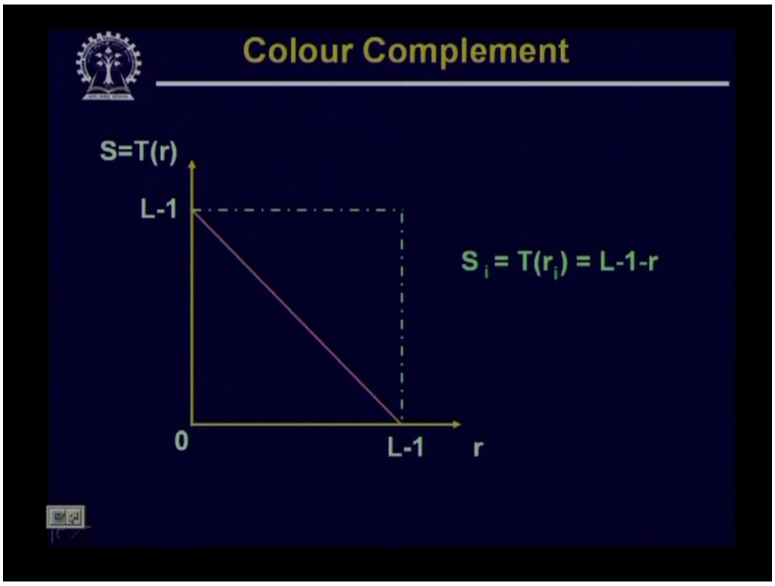

So, those color images can be obtained by a transformation function of this form in case of intensity image we had a single transformation but in case of color image I have to apply the same transformation on all the color planes that is I have to get it si equal to t of ri which is equal to l minus 1 minus ri this should be ri for all values of I that means here I will be from 1, 2 and 3 that is for all the color planes red, green and blue I have to apply this same transformation.

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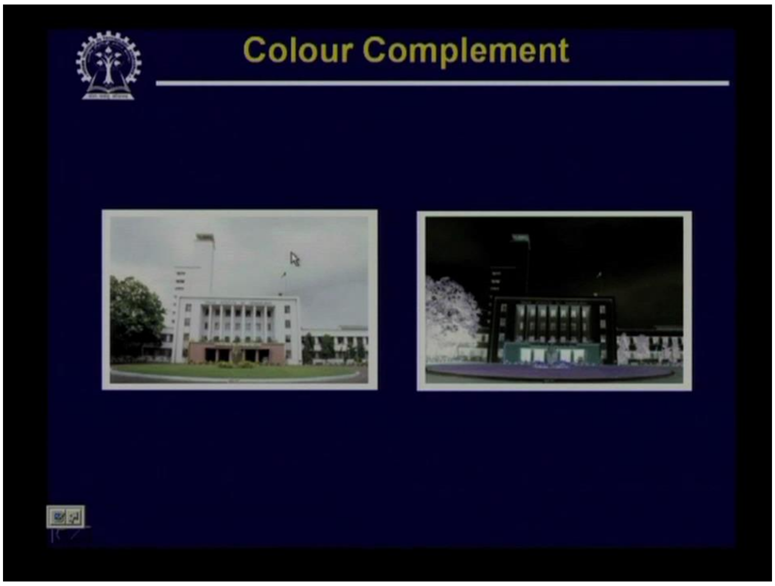

So, by applying this I get uhh I an image like this, here you find that left hand side I have a color image and on the right hand side by applying the same transformation on all the three planes that is red, green and blue planes I get a compliment image or you find that this is same as the photographic negative of my color image. In the same manner this is another color image and if I apply the same transformation to the red, green and blue components of this particular color image then I get the corresponding negative or the compliment color image as shown on the right hand side.

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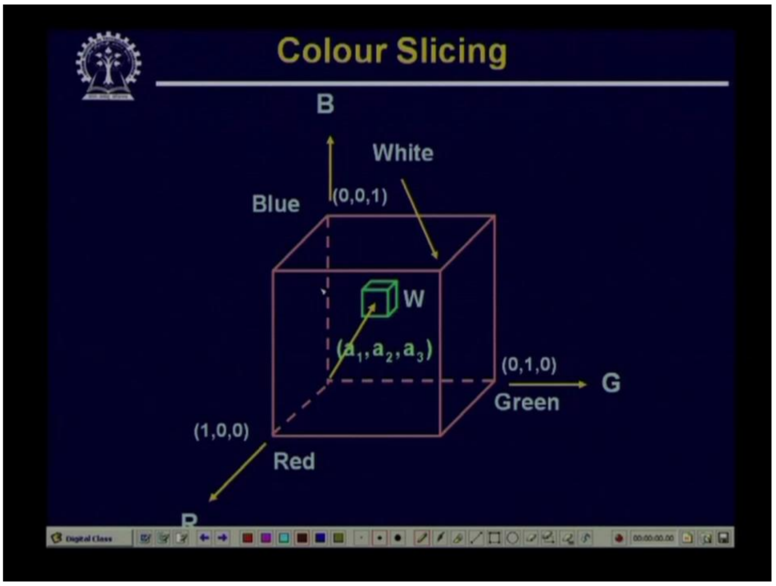

The next application that we will consider of this full-color image processing is color slicing. You find that in case of rgb image we have said that the application of color slicing is to highlight the regions of certain intensity uhh ranges certain intensity region. In the same manner the application of color slicing in case of color image is to highlight certain color ranges and this can be applied this is useful for identification of objects of certain color from the background or to differentiate objects of some color from some other color.

The simplest form of color slicing can be that we can assume that all the colors of interest lies within a cube of width say w and this cube is uhh centered at a prototypical color whose components are given by some vectors say a1, a2 and a3. So, as given in this particular diagram. So, here I assume that I have this cube of width w which under colors of interest are contained within this cube and the center of this cube is at a prototypical color which is given by the color components a1,a2 and a3.

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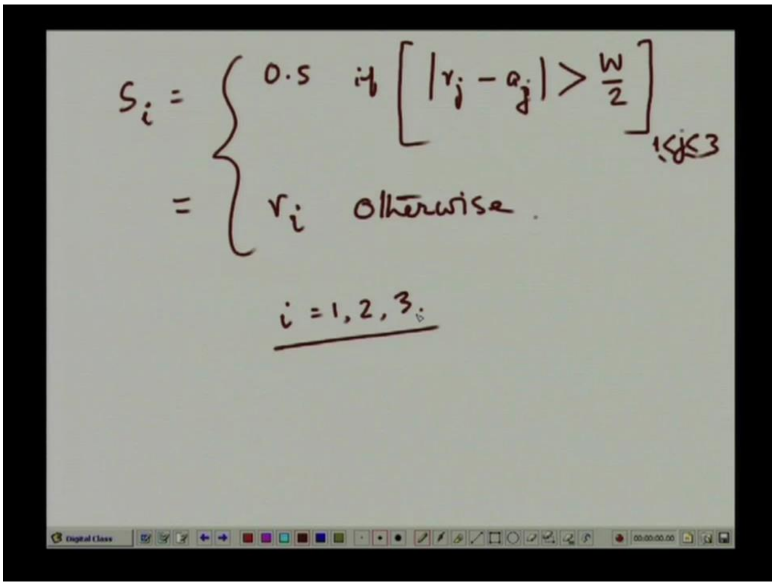

And the simplest type of transformation that we can apply is we can have the transformation of this form that si is equal to 0.5 if say rj minus aj this is equal to w by 2 for all values of j in one and three and I said this is equal to ri otherwise. Okay and this computation has to be done for all values of i, I equal to 1, 2 and 3.

So, what it means that all those colors which lies outside this cube of width w centered at location a1, a2 and a3 all those colors will be represented by some insignificant color where all the red, green and blue components will attain a value of 0.5. But inside the cube I will retain the original color.

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So, by using the this transformation you find that from this color image if I want to extract the regions which are near to red then I get all those red component as extracted in this right image and for all other points where uhh the color is away from red you find that they have got a gray shade.

Now, for this kind of application instead of considering all the colors of interest lying within the cube we can also consider all the colors to be lying within a spherecentered at location a1, a2 and a3. So, here it is needless to say that if the vector the central location a1, a2 and a3 this tells you that what is the color of interest and the width of the cube or the radius of the sphere whichever may be the case tells us that what is the variation from this prototype color that we say that those colors are also of interest.

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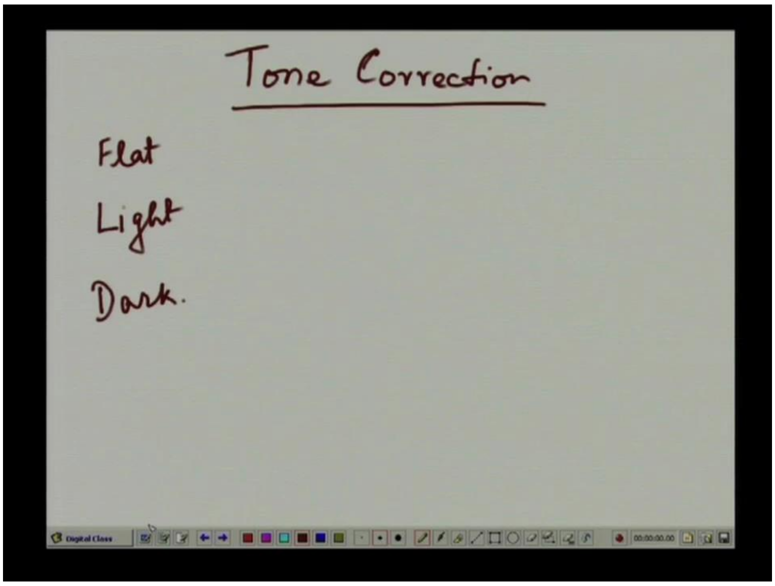

The other kind of application of this full color image processing is say correction of tones or tone correction. Now, again I can find on analogue in intensity image in a simple black-n-white intensity image where we have said that an image can be low contrast it may be uhh an image may be dark it may be light uhh or bright or it may be low contrast depending upon distribution of the intensity values. In the same manner for color images we define the tone.

So, a color image may have a flat tone, it may have a light tone or it may have a dark tone and these tones are determined by the distribution of the intensity values of different rgb components within the image. So, let us see that how these images look like in case of a color image.

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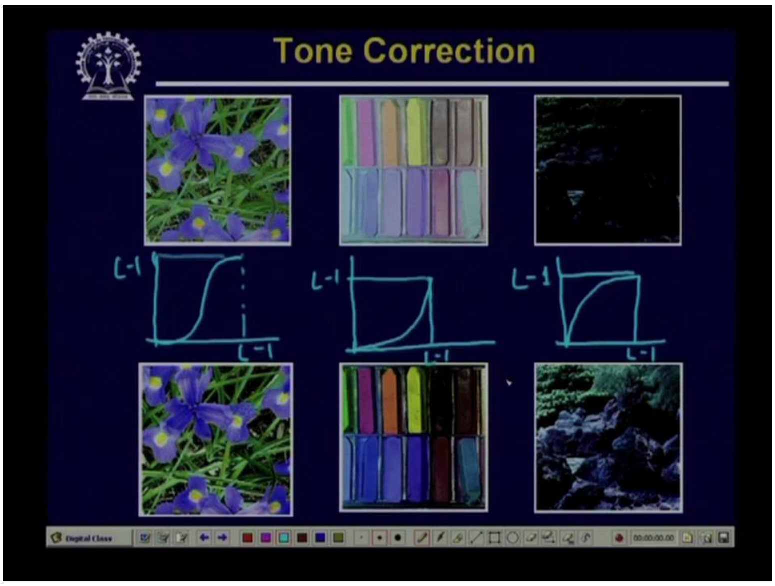

So, here you find uhh that on the left we have shown a an image which is flat in nature in the middle we have an image which is having light tone and on the extreme right we have an image which is having dark tone.

Now, the question is how we can uhh correct the tone of this color image? Again we can apply similar type of transformations as we have done in case of intensity image for contrast enhancement. So, the kind of transformations that we can be that can be applied here is something like this. If an image is flat the kind of transformation function that we can use for this flat image is of this form. So, here it is l minus 1, here also it is l minus1. So, if you apply this type of transformation to all the red, green and blue components of this flat image what we get is a corrected image.

Similarly, an image which is light whose tone is light here also we can apply a kind of transformation, here you find that what is needed to be done is uhh if this image appears to be darker then that will be a corrected image. So, the kind of transformation that we can apply is something like this. So, here it is l minus 1, here also it is l minus 1. So, here what happens is a wide range of intensity values of the intensity values in the input image is mapped to a narrow range of intensity values in the output image. So, that gives you the tonal correction for an image which is uhh light.

Similarly, for the image which is dark the kind of transformation that can be applied here is just reverse of this. So, the transformation that we will apply in this case we will have this type of nature. So, here we have l minus 1 that is the maximum intensity value here also we have the l minus 1 that is maximum intensity value. So, here the kind of operation that we are doing is a narrow range of intensities in the input image is mapped to a wide range of intensities in the output image.

So, by applying these types of transformations we can even go for tonal correction of the color images. Of course the other kind of transformation that is histogram based processing can also be applied for uhh color images as well where the histogram equalization or histogram matching kind of techniques can be applied on different planes different color planes red, green and blue color planes of the input color image. And of course uhh in such cases in many cases it is necessary that after the processing the processed image that you get that need to be balanced in terms colors.

So, all these different color image processing techniques that we have discussed till now you find that they are equivalent to point processing techniques that we have discussed in connection with or uhh intensity images or black-n-white images uhh. Now, in case of our intensity image we have also discussed another kind of processing technique that is the neighborhood processing technique. Similar neighborhood processing technique can also be applied in case of color images where uhh for processing an image it is not only the color at a particular intensity location that we will consider but we also consider the colors at the neighboring intensity values.

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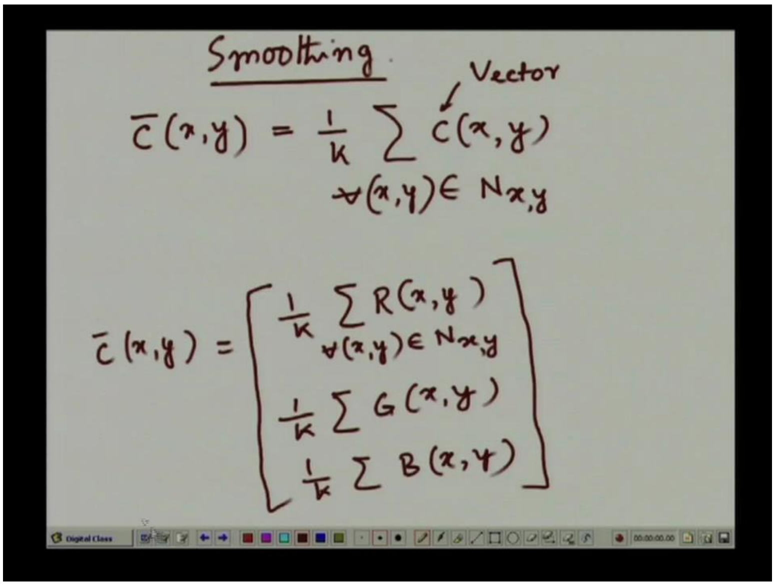

So, we will talk about two such processing operations the first one that we will consider in this category is smoothing operation. So, for this smoothing what will have is uhh that the in a smooth image the color components c(x, y) c bar x y uhh will be given by one over k summation of c(x, y). So, where the c(x, y) this is actually a vector having three components uhh in rgb space this will be red, green and blue components and this averaging has to be done for all x y for all locations xy which is in the neighborhood of point x y. Okay.

So, here I can uhh simply do this operation in a plane wise manner where we can write that c bar (x y) is nothing but one over k into summation r(x, y) for all xy within the neighborhood of n xy. Similarly, one upon k summation of g(x,y) again for all xy within the neighborhood of n x y and one over k summation of b(x, y) where again this summation is carried out over the same neighborhood of xy and these vectors the average of these vectors gives us is called the smooth image.

So, the smooth image in this particular case we find that on the left hand side we have the original color image and of the right hand side have the smooth image where this smoothing is carried over uhh a neighborhood size of side by side. So, as we have done the smoothing operation in the same manner we can also go for sharpening operation and we have discussed in connection with our intensity images that an image can be sharpened by using uhh second derivative operators like laplacian operator.

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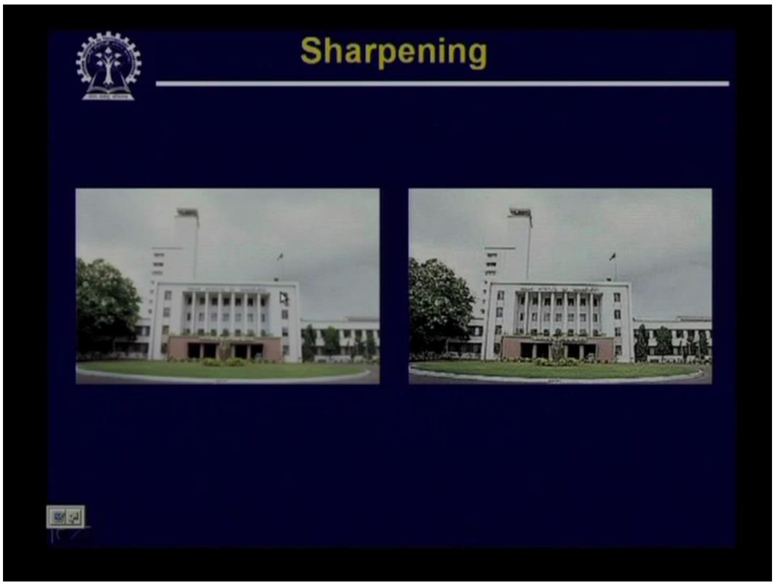

So, here again if I apply the laplacian operator on all three planes the red plane, green plane and the blue plane separately and then combine those results what I get is a sharpened image. So, by applying that kind of sharpening operation a sharpened image can appear something like this. So, here on the left hand side we have showed original image and on the right hand side you find that the image is much more sharp than the image on the left.

Now, we know go for this neighborhood operations like image smoothing or image sharpening, the type of operations that we have discussed is uhh the per color plane operation that is every individual color plane is operated individually and then those processed color planes are combined to give you the colored processed image. Now, as we said the same operation can also be done by considering the vectors.

Okay or if I do the same operation in the hsi color plane where we can modify only the intensity component keeping the hs components unchanged. In such cases it the results that you obtained in the rgb plane and the result that obtained in case of hsi plane may be different and I give u as an exercise to find out what why this difference should come. So, with this we finish our discussion on color image processing. Thank you.