Digital Image Processing
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Module 11 Lecture Number 53
Conversion of one Color Model to another – 2

Hello, welcome to the video lecture series on Digital Image Processing.

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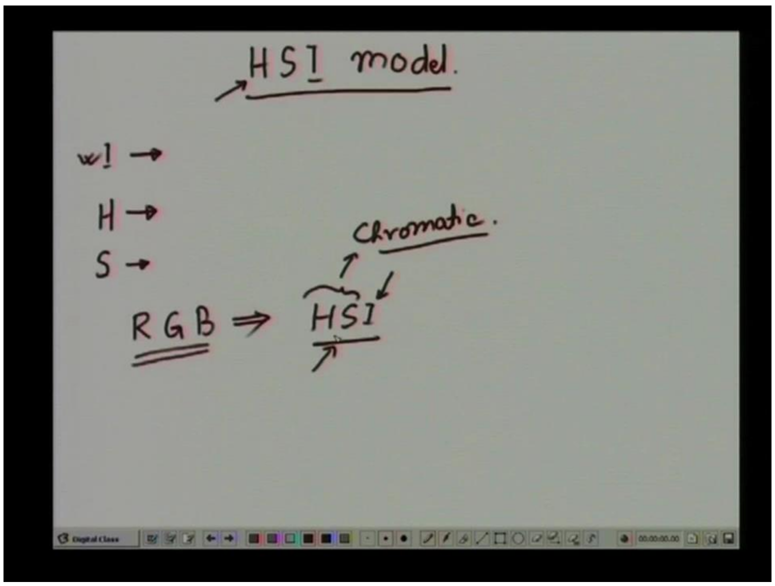

Now the mixed colour model that will consider is the H S I colour model that is Hue, Saturation and Intensity model. So as we have mentioned in our (la) last class that both the R G B as well as C M Y or C M Y K, they are actually hardware oriented. The R G B colour model is oriented towards the colour display or colour monitor, similarly C M Y or C M Y K these two models are oriented toward colour printers. Whereas when it comes to human interpretation, we said that we do not really think of that given any particular colour, how much of red, how much of green and how much of blue is contained within in that particular colour.

But what we really think of is, what the prominent colour in that particular specified colour. So which is what is known as Hue. Similarly, we have said the Saturation; it indicates that how much a pure spectrum colour is really diluted by mixing white colour to it. So, if you mix white colours to a pure spectrum colour in different amounts, what we get is different shades of that particular spectrum colour, and as we said that I the Intensity this actually is the chromatic notion of brightness of black and white image.

So what we have is Hue, which tells us that what is the prominent colour, prominent primary colour or spectrum colour in that particular specified colour. we have the Saturation, which indicates that how much white light has been added to a pure spectrum colour to diluted and we have this component Intensity, which is actually a chromatic notion of the brightness, ok.

Now the given is problem is given a colour in R G B space, can we convert that to H S I space? Now this H S I model has other importance also in in addition to just a interpretation by in addition to human interpretation, because we find that this H S I model, it decouples the Intensity information from the colour information. So this I gives you the Intensity information, whereas H and S, the Hue and Saturation together this gives you the chromatic information.

So as we can decouple the chromatic information from the Intensity information many of the image processing algorithms which are developed for black and white image or gray scale images can be applied to this H to the images specified in H S I space. So conversion of an image from the R G B space to the (H I space) H S I space is very very important.

Now, let us see that how we can convert an image specified or a colour specified in R G B space to the to a colour in the H S I space. Now in order to do this what we can do is we can reorient the R G B cube the R G B space. In such a way that the black point or the origin in the R G B cube is kept at the bottom and the white comes directly above it, so as shown here.

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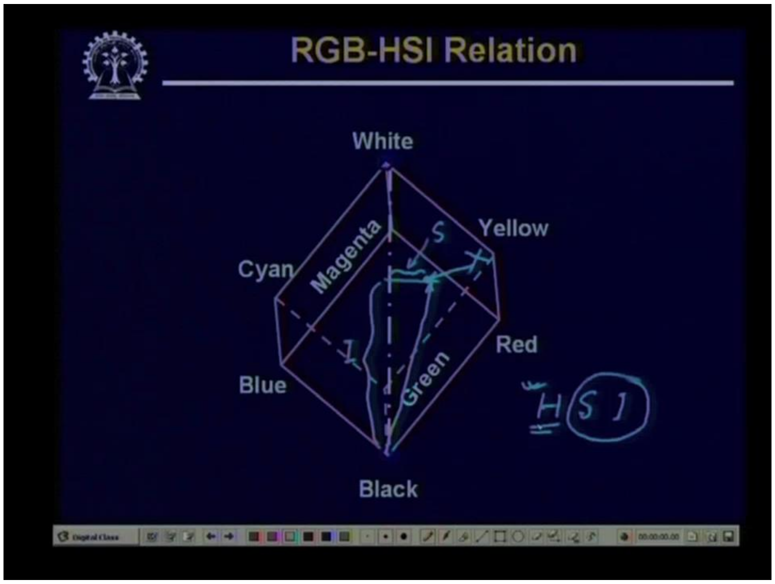

So find that it is the same R G B cube and what we have done is we have simply reoriented this R G B colour cube. So that the black comes at the bottom so this is the black one, the black comes at the bottom, and the white comes directly above this black point. So naturally as before the line joining black and white this represents the Intensity axis ok. Which show any point on this particular line which joins black and white, they will not show any colour information but they will have different intensities or different gray shades.

Now once we have once we reorient this R G B cube like this. Now suppose we have a colour point. We have any colour point specified within this R G B cube. So, I have this colour point specified in the R G B space. Now for this colour point, now our aim is how we can convert this R G B specification into H S I specification. So as we said that the line joining black and white, this line is the Intensity axis. So in the H S I space, I can very easily compute the Intensity component because for this point (say) I say this is a point say x. I can represent this point as a vector joining from black to this particular point, and the Intensity component that is associated with this R G B value is nothing but projection of this vector on the Intensity axis.

So if I project this vector on the Intensity axis then the length of this projection tells us, what is the Intensity component associated with this particular RGB specified colour point ok. Now what to get this what I can do is, we can draw a plane we can just pass a plane, which is perpendicular to the Intensity axis and containing this particular point x. So the point at which this plane will cut the intensity axis that point represents the that associated with the R G B components specified for this particular point x. So this is how we can compute the in that component and then you find the next component that is the Saturation.

How we can compute, so this one tells us that what is the Intensity. Now how can we compute the Saturation, because the line joining black and white the intensity axis any point on the Intensity axis has only gray shades this does not have any colour component. So we can say that the Saturation of all the R G B point, the Saturation associated with all the RGB points lying on that this Intensity axis is equal to zero, and the Saturation will increase as the point will move away from this Intensity axis.

So keeping that in mind we can say the distance of this point X find this Intensity axis, this distance tells us that what is the Saturation that is associated with the R G B components of point X. So we can very easily compute the Intensity and Saturation corresponding to any R G B point given in the space. Now the next question is the computation of the Hue component, so out of Hue Saturation and Intensity. We have been able to compute the Saturation and Intensity very easily. The next component which is left is the Hue component.

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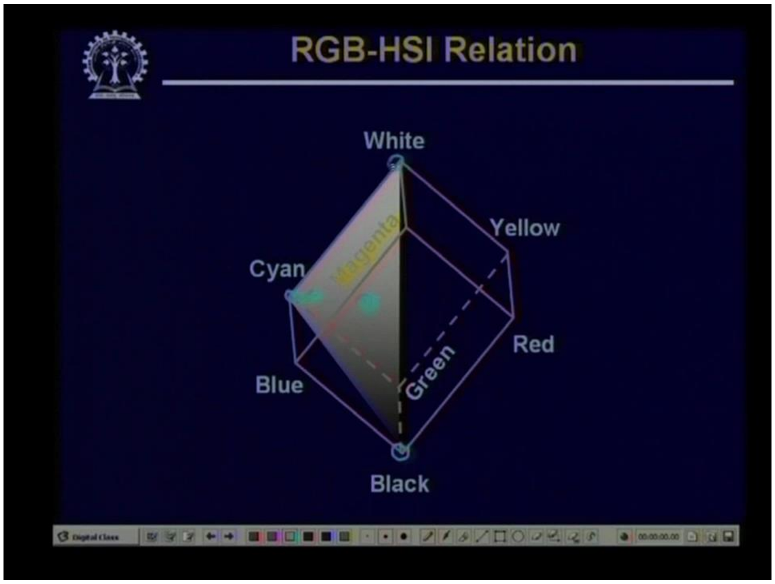

Now for the Hue component computation the concept is slightly more complicated. Now we find that in this diagram we have shown a plane passing through the points black, white and cyan. So as we said that the line joining black and white is the Intensity axis so Intensity at point black is equal to zero and Intensity at point white is maximum that is equal to one and the other point, which defines this particular plane is the cyan that is this particular point. Now we will appreciate that for any points in this particular plane define by this three points black, white and cyan we will have the same Hue, because as we said that Hue indicates that what is the prominent wavelength of light present in any particular colour.

And from our earlier discussion we can you can also very easily verify that for any point given on this particular plane define by this three points cyan, white and black. For any points, the colour components can be specified the linear combination of this three points cyan, white and black. Now because white is a balanced colour which contains all the primary component in equal proportion and black does not contain any colour component so this two point white and black cannot contribute to the Hue components associated with this point lying in this plane. So the only point which can (comp) contribute to the Hue component is the cyan.

So for all the point lying in this plane the Hue will be same and it will be same as the Hue associated with this point cyan. So here we find that if I rotate this particular plane around, this black and around the Intensity axis by an angel of 360 degree then I trace all the possible points (speci) that can be specified in the R G B colour space. And by tracing the rotating this plane by (3) 360 degree around the Intensity axis I can generate all possible Hues that can be, all possible Hues corresponding to every possible R G B point in the R G B colour cube.

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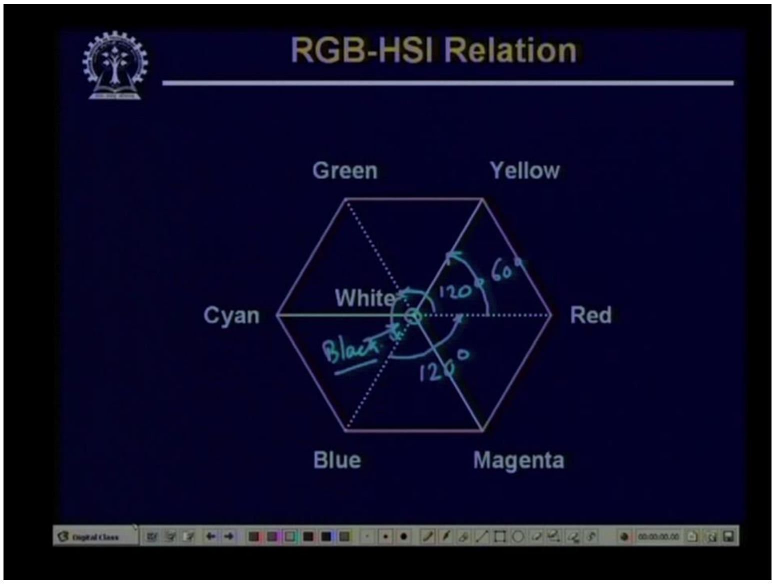

Now in to order to that what I do is like this. Suppose I take projection of this R G B cube or a plane, which is perpendicular to the Intensity axis. So if I take the projection then the different vertices of the cube will be projected on a hexagon as shown in this particular figure. So the cube vertices corresponding to red and black they will be projected at the center of the hexagon. So this point will be the projected point for both white and black and the other primary colures of light and the primary colours of pigments they will be projected at different vertices of the hexagon.

So here we find that if I draw a vector or if I draw a lines joining the center of the hexagon to all the vertices of the hexagon then red and green they will be separated by an angel of 120 degree. Similarly, green and blue they will be separated by an angel of 120 degree, similarly blue and red they will be also separated by an angel of 120 degree. In the same manner for the secondary colours yellow and cyan they will be separated an angle of 120 degree, cyan and magenta will be separated by angle of 120 degree and similarly magenta and yellow they will be also be separated by an angle of 120 degree.

However the angular separation between red and yellow this is equal to 60 degrees. So if I take the projection of the R G B cube on a plane which is perpendicular to the Intensity axis then this is how the projection is going to look like.

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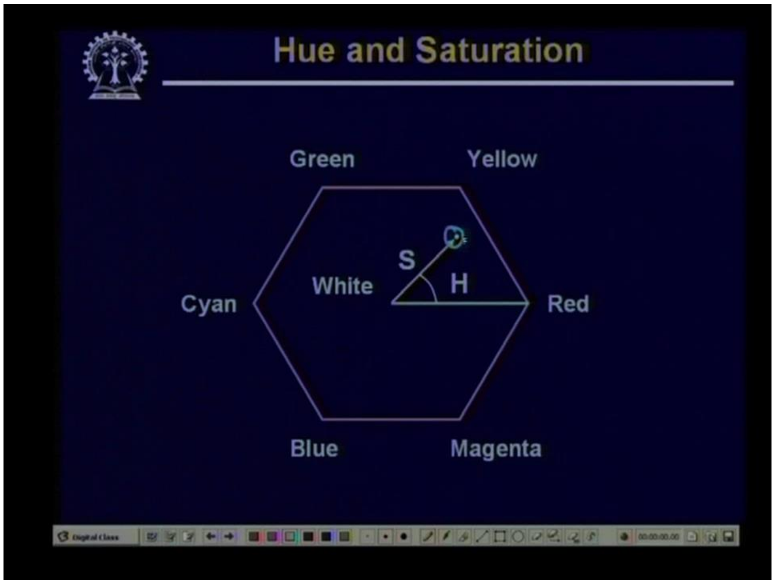

Now along with this we will find that the projection of the shaded plane that we have seen in our previous slide will be a straight line like this. So for any point specified in the R G B colour space there will be a corresponding point in our projected plane, say this is plane corresponding to a colour point in the R G B colour space. And the plane on which this colour point will lie this the plane defined by that corresponding colour point the black point and white point on which this point will lie that will be projected as a straight line on this particular plane.

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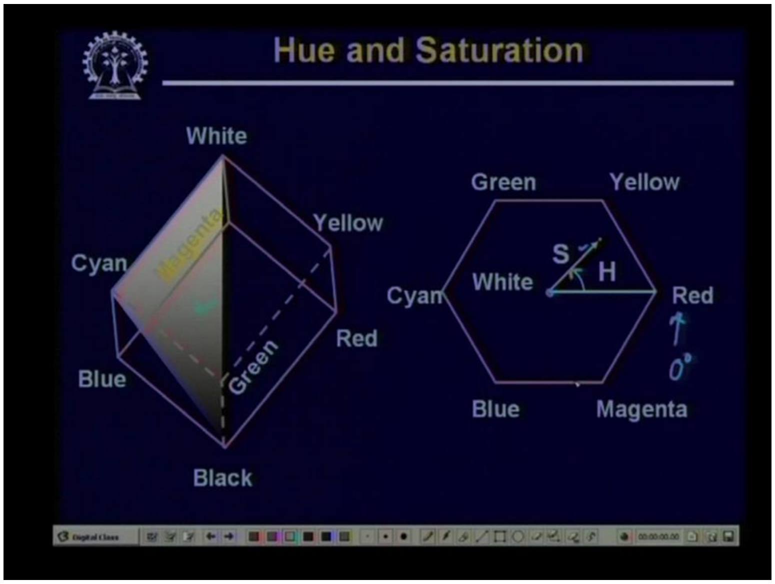

So as we rotate the plane by 360 degree around the Intensity axis this particular straight line will also be rotated by an angle of 360 around the center of the hexagon. So if I rotate this particular shaded plane by an angel of 360 degree around this black and white axis of the Intensity axis. It is projection on to the plane, on to this perpendicular plane which is a straight line will also be rotated by an angle of 360 degree around the center of this hexagon.

Now this gives us a hint that how we can find out the Hue associated with a particular colour point specified in the R G B colour space. So the Hue can be computed like this that the straight line it is the angle between the straight line which is the projection of this shaded plane with one of the primary colours and normally this primary colour is taken to be red. And this angle is normally is measured in anti-clock wise direction. So that using this particular convention the red will have a Hue which is given by zero degree and as we rotate this shaded plane along the around Intensity axis. This particular straight line which is the projection of it we will also be rotated by 360 degree and as it is rotated the Hue is going to be increased.

So Hue is normally by the angle between the red axis and the line which is the projection of this plane on this projection of this shaded plane on this plane of this hexagon. Now given this particular concepts that is how we can obtain the Hue, Saturation and Intensity components for any colour specified in R G B colour space. Now we can find out that if you follow the geometry of this particular formulation then we can have very easy relations to compute the H S and I components from the R, G and B components.

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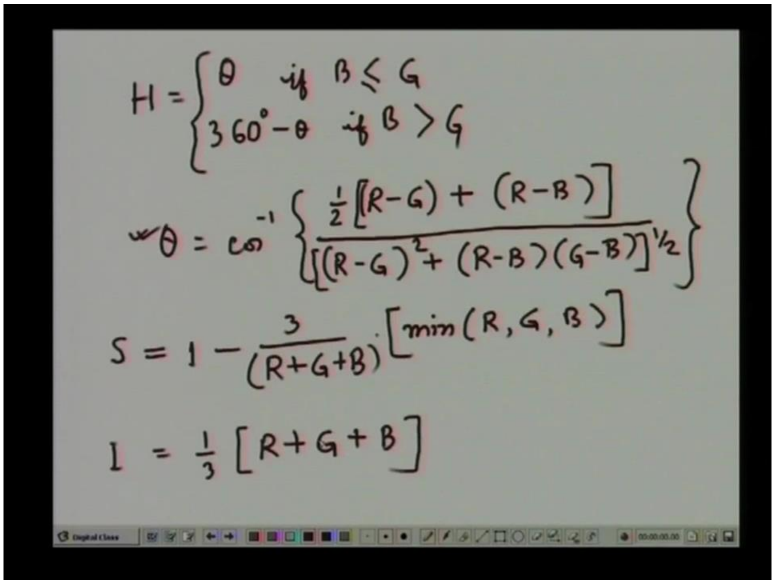

So here the Hue component the H will be simply given by an angle theta and as we said that this theta is measured anti clockwise from the direction of red. So this will be equal to theta if the blue component is less than or equal to green component and it will be 360 degree minus theta, if blue component is greater than the green component.

So this is how we can compute the Hue components in the H S I (specif) model, but the value of theta is given by cosine inverse half of R minus G plus R minus B divided by R minus G square plus R minus B into G minus B this to the power half. Where R is the red component, G is the green component and (blue) B is the blue component of the colour specified in the R G B space.

So from this R G B component we can compute the value of theta following this expression, and from this theta we can find out the Hue component in the H S I space as Hue will be equal to theta, if blue component is less than or equal to green component, and Hue will be equal to 360 degree minus theta if blue component is greater than green component is greater than green component.

Similarly, following the same geometry we can find out that the Saturation is given by 1 minus 3 divided by R plus G plus B into minimum of R, G and B and the Intensity is simply given by 1 third into R plus G plus B. So from this red, green and blue components we can very easily find out the Hue, Saturation and Intensity components.

So as we have converged from RGB space to the H S I space, similarly, we should also be convert any colour specified in H S I space into the components in the R G B space. So to do that conversion of the inverse conversion the corresponding expressions can be found as you find that whenever want to convert from the H S I to R G B then there are three region of interest.

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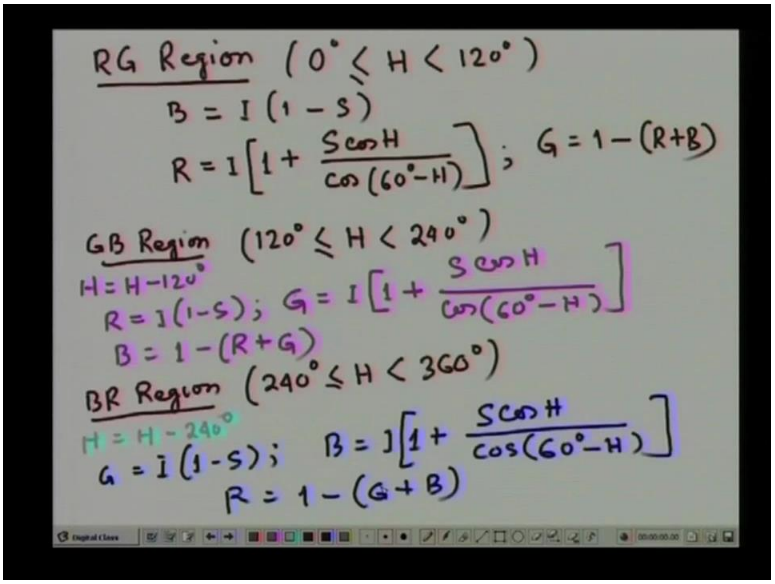

One region is called R G region, and in R G region H lies between 0 degree and 120 degree. The other region is called G B region, and in G B region H lies between 120 degree and 240 degree. And the third region is called B R region and in B R region H lies between 240 degree and 360 degree and here in the R G region you find that getting red, green and blue components in very easy is very easy.

What I do is? Simply the blue component is given by I into 1 minus S or I is the Intensity and S is the Saturation. The red component is given by I into 1 plus S cosine H divided by cosine 60 degree minus H and green component is simply given by 1 minus R plus B. Similarly in the G B region the first operation that we have to do is we have to modify H, so we have to make H is equal to H minus 120 degree. And once we do this we get the R G and B components like this, R is equal to I into 1 minus S, G is given by I into 1 plus S cosine H divided by cosine 60 degree minus H and blue in the same manner is given by 1 minus R plus G.

And in the third sector that is in the B R region we have to modify first H like this H should be equal to H minus 240 degree and once we do this modification then the G component is given by I into 1 minus S. The blue component is given by I into 1 plus S cosine H divided by cosine 60 degree minus H and obviously the R component is given by 1 minus G plus B. So you find that using this simple expressions we can convert a colour specified in the R G B space to a colour in the to the colour components in the H S I space. Similarly a colour specified the H S I space can be easily converted to colour components in the R G B space.

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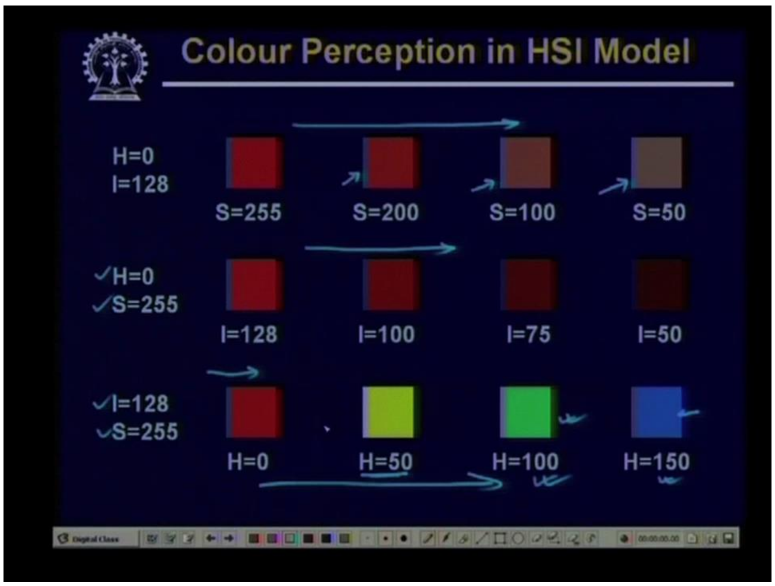

So here in this diagram we have shown a the effects of this different components H S and I on the colours. So in the first row you find that the first rectangle is a colour for which Hue is equal to zero, Intensity is equal to 128 and Saturation is equal to 255. So as we said that our Hue is measured from the red axis form the red line so Hue equal to zero indicates that it is red colour. In this case the Saturation is equal to 255 which is the maximum that means it is the pure red colour and Intensity here is 128.

So for other rectangles in the same row what we have done is we have kept Hue and Intensity constant whereas the Saturation is decreased. So here we find that as we move from left to right it appears that this red has become is becoming milky gradually. So as we have Saturation is equal to 200 which is less than 255, it appears that some amount of white light has been added in this particular red component, and that is very very prominent when S is equal to 100 or even so is equal to 50, where a large amount of white light has been added in this red component.

In the secondary row what we have done is we have kept is Hue and Saturation constant that is Hue equal to zero and Saturation equal to 255 and what we have varied is the Intensity component or the I component. So here we find that as we decrease the I component the different rectangles still show the red colour as we move from the left to right in the second row they are still red but the Intensity of the red goes on decreasing.

So if you just note the difference between the first row and the second row, in the first row it appears that some white light has been mixed with red. Whereas in the second row there is no such appearance of mixing of white light but it is the Intensity which is being decreased. If you look at the third row in the third row what you have done is, we have kept is the Intensity and the Saturation constant but it the Hue component which has been changed.

So we have started with Hue equal to zero which is red and here you really find that as we change the Hue component it is really the colour which gets changed. Unlike the previous two rows, in the first row it is the Saturation or more and more white light is being added to the pure colour in the second row the Intensity is getting changed, but in the third row where keeping the Intensity and Saturation same which is the Hue component it is the colour itself that gets equal to changed.

So here you find that when we have Hue is equal to 100 it is the green colour, when we have Hue equal to 150 it is the blue colour. Whereas when Hue is equal to 50 it is a colour between a yellow and green. So with this we have introduced the various colour models we have include introduced the R G B colour space. We have introduced C M Y or cyan, magenta and yellow colour space and also C M Y K that is cyan, magenta, yellow and black colour space. And we have also introduced the H S I colour space and we have seen that given any colour given the specification of any colour in any of the spaces we can convert from one space to another, that is from RGB to C M Y, the conversion is very easy. We can also convert from R G B to H S I, where the conversion is slightly more complicated.

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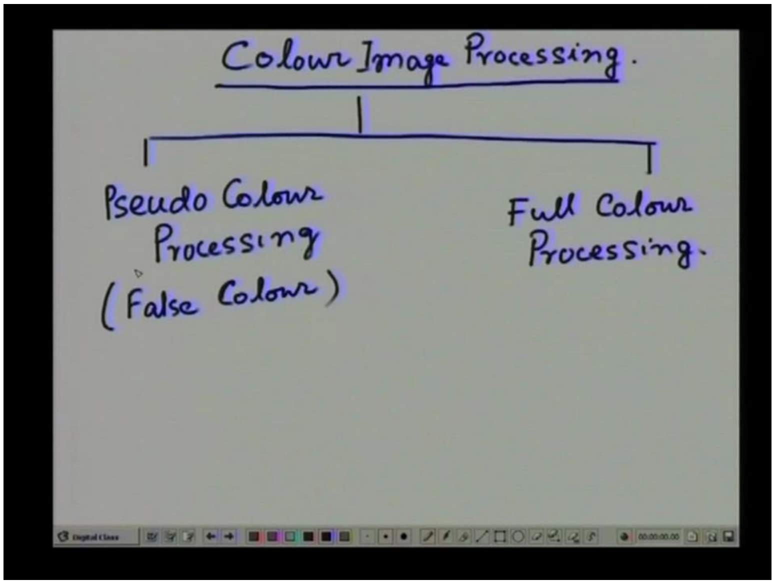

Now with this introduction of the colour spaces, next what we will talk about is the color image processing. So far what we have discussed is the representation of a colour of the representation and one we take as an image take the colour component the colours present in the image. There is so far we discussed how to represents those colours in either the R G B, R G B plane or C M Y or C M Y K space or the H S I space, and the images represented in any of this models can be processed.

So in color image processing we basically have two types of processing, one kind of processing is called Pseudo colour processing. This also sometimes known as False colour and the other kind of processing is what is called Full color processing. In Pseudo colour processing as the name implies that these colours are not the real colours of the image but we try to assign different colours to different Intensity values.

So Pseudo colour processing actually what it does is, it assigns colours to different ranges of gray values based on certain criteria. Now what is purpose of assigning colours to different ranges of gray values, as we have mentioned earlier that if we have a simply black and white image, we can distinguish hardly to dozens of the gray shades whereas in colour we can distinguish thousands of colour shades.

So given a gray scale image or an simply black and white image if we can assign different colour to different ranges of gray values then the interpretation of different ranges of gray values is much more easier in those Pseudo colour images than in the gray scale images. So we will discussion about how we can go for Pseudo colouring of an image given in the R Pseudo colouring of a black and white image.

So as we said that this colouring has to be done following some criteria. So with this introduction and of course in case of full color processing as the name indicate, the images are represented in full color and the processing will also be used, processing will also be done in the full color domain. So given this introduction of the colour processing techniques, the two types of colour processing, Pseudo colour processing and full color processing. We finish our lecture today, thank you.