Digital Image Processing

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Lecture - 27

Colour Image Processing – II

Hello, welcome to the video lecture series on digital image processing. In our last class, we have started our discussion on colour image processing.

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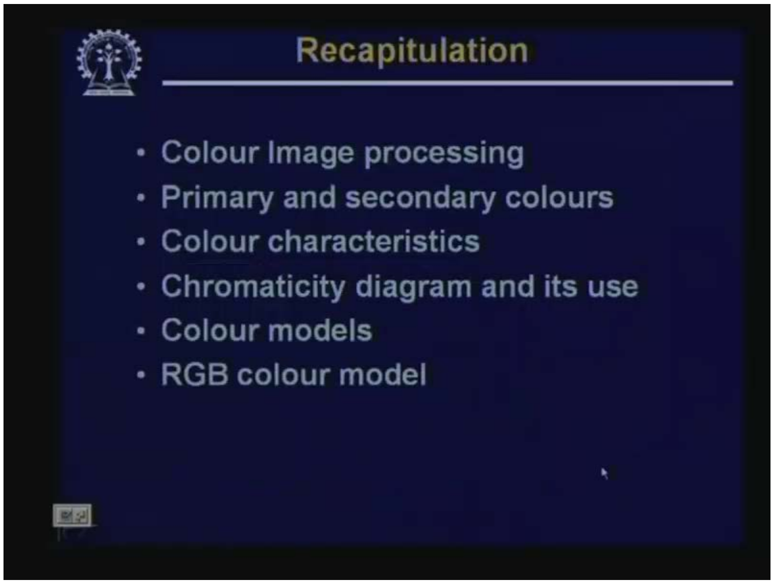

Recapitulation

- Colour Image processing
- Primary and secondary colours
- Colour characteristics
- Chromaticity diagram and its use
- Colour models
- RGB colour model

So, in our last class, the topics that we have covered are the fundamentals of colour image processing, we have seen what is a primary colour and what is secondary colour, we have seen the characteristics of different colours, we have seen the chromaticity diagram and the use of the chromaticity diagram and we had started our discussion on colour models and there, we just started that discussion on RGB colour model.

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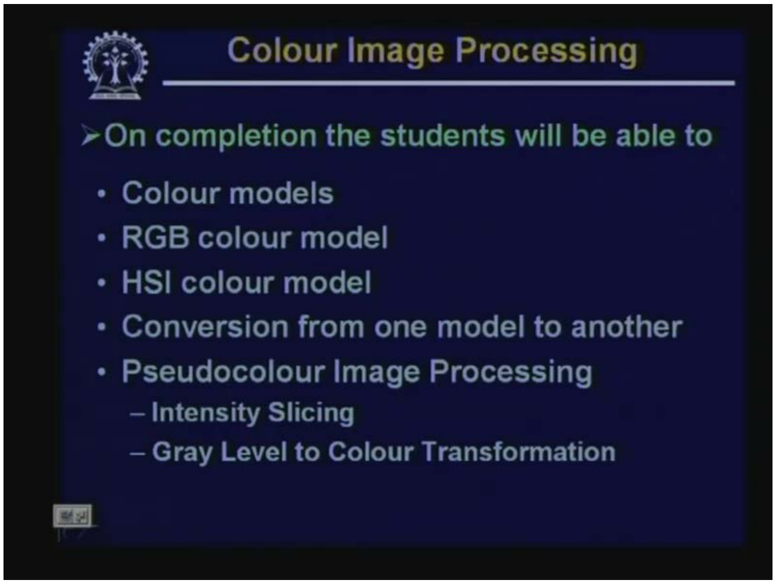

Colour Image Processing

➢On completion the students will be able to

- Colour models
- RGB colour model
- HSI colour model
- Conversion from one model to another
- Pseudocolour Image Processing
  - Intensity Slicing
  - Gray Level to Colour Transformation

Today, we will start our discussion with the colour models. So, we will complete our discussion on RGB colour model. We will also talk about the HSI or hue saturation and intensity colour model. We will see how we can convert the colours from one colour model to another colour model. That is given a colour in the RGB space, how we can convert this to a colour in the HSI space and similarly, given a colour in the HSI space, how we can convert that to the RGB space.

Then, we will start our discussion on image colour image processing techniques. So, we will talk about pseudo colour image processing and there, mainly we will talk about 2 techniques. One is called intensity slicing and the other one is gray level to colour image transformation.

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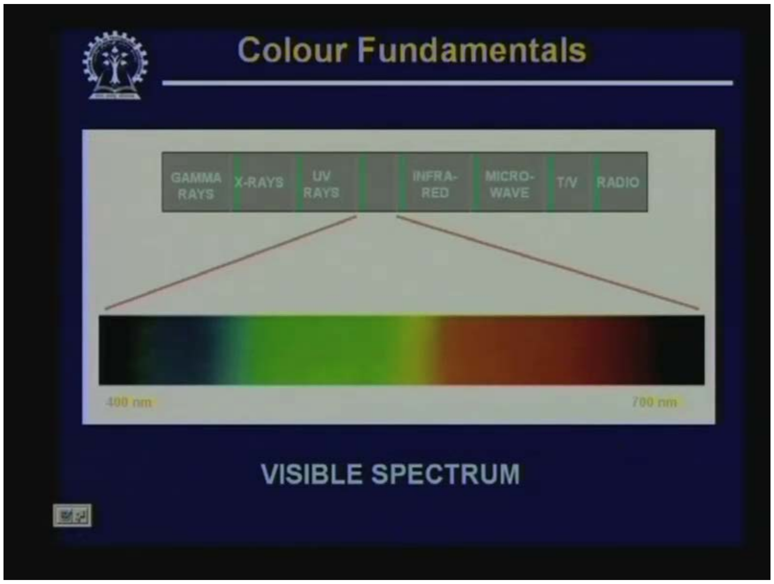

Colour Fundamentals

VISIBLE SPECTRUM

So, let us just briefly recapitulate what we have done in the last class. In the last class, we have mentioned that all the colours of the visible light or the visible spectrum, colour spectrum occupies a very narrow spectrum in the total electromagnetic band of frequencies or band of spectrum and the visible spectrum, the wavelength normally varies from 400 nanometer to 700 nanometer. So, at one end, we have the violet and in the other end, we have the red colour.

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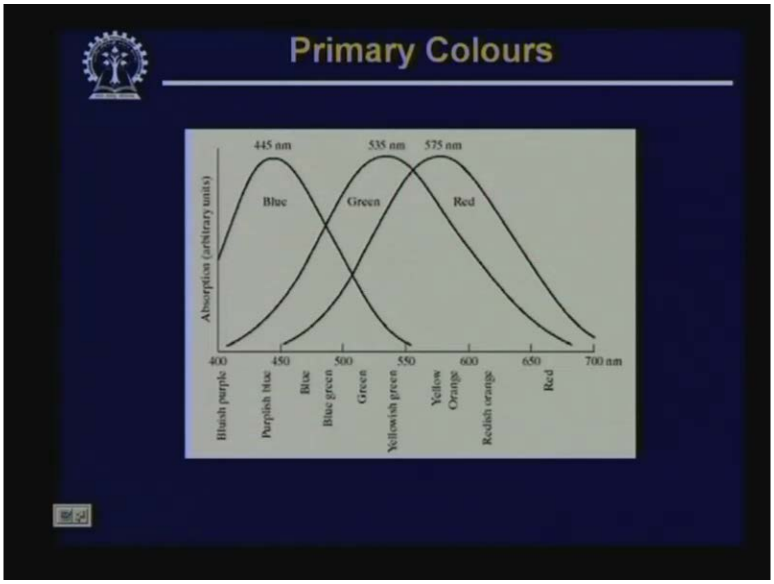

Primary Colours

And out of this, we normally take 3 colour components that is red, green and blue as the primary colour components because we have mentioned that in our eye there are 3 types of cells, cone cells which are responsible for colour sensation. There are maximum there are some cone cells which are responsible which sense the light in the red wave length, there are some cone cells which sense the green light and there are some cone cells which sense the blue lights and these lights are mixed together in different proportions in an appropriate way so that we can have the sensation of different colours.

And, this is the main reason why we say that red, green and blue; they are the primary colours and by mixing these 3 primary colours in different proportion, we can generate almost all the colours in the visible spectrum.

Then, we have talked about 2 different colours, 2 types of colours; one is the colour of light, other one is the colour of the pigment. Now, colour of the light: as we see any particular object, we can see the colour which is reflected from the object because of the wavelength of the light which gets reflected from the object surface. Now, when it comes to pigment colour and a colour falls on it, then the pigment colour, it absorbs the particular wavelength out of the 3 primary colours and reflects the other wave lengths.

So, the primary colours of light are really the secondary colours of pigment and the secondary colours of light, they are the primary colours of pigment and because of this, the colours of light, they are called additive primaries whereas the colours of the pigments they are called subtractive primaries.

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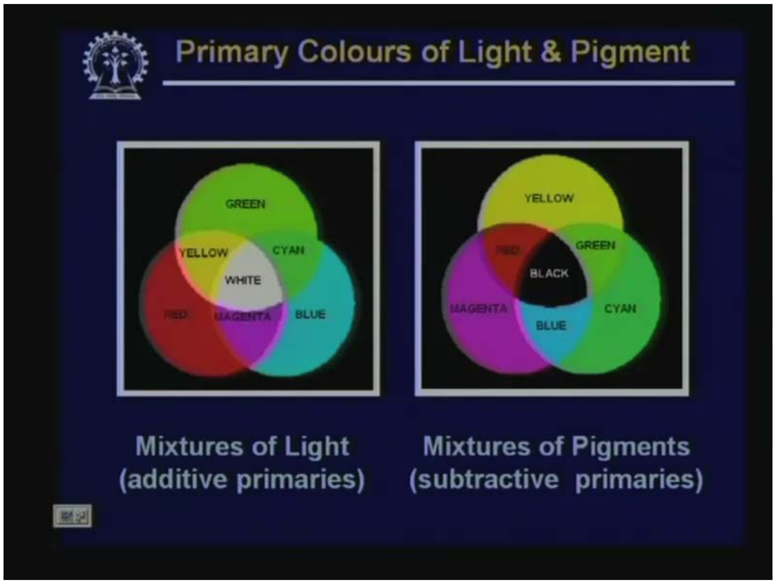

Primary Colours of Light & Pigment

Mixtures of Light
(additive primaries)

Mixtures of Pigments
(subtractive primaries)

And here, you can see in this particular slide that the 3 primaries of light - red, green and blue when they are mixed together, then red and green mixed together form what is called form the yellow light. Then, green and blue when they are mixed together, these 2 forms the cyan. And, red and blue mixed together form the magenta. And, red, green and blue; all these 3 colours together form what is the white light.

Similarly, when it comes to pigment primaries; yellow which is a secondary colour for light is a primary colour of a pigment. Similarly, magenta which is a secondary colour of light is also a primary colour of pigment. Cyan which is a secondary colour of light is a primary colour of pigment. And here, you find that when this pigment primaries, they are mixed together; then they form what are the primary colours of light.

So, yellow and magenta, these 2 together form the red light. Yellow and cyan mixed together form the green light and magenta and cyan joined together mixed together form the blue light. However, all these 3 pigment primaries that is yellow, magenta and cyan mixed together form the black light. So, this is the black colour. So, by mixing different colours of light or the different colours of different colours of primary colours of light or different primaries of the pigment, we can generate all types of different colours in the visible spectrum.

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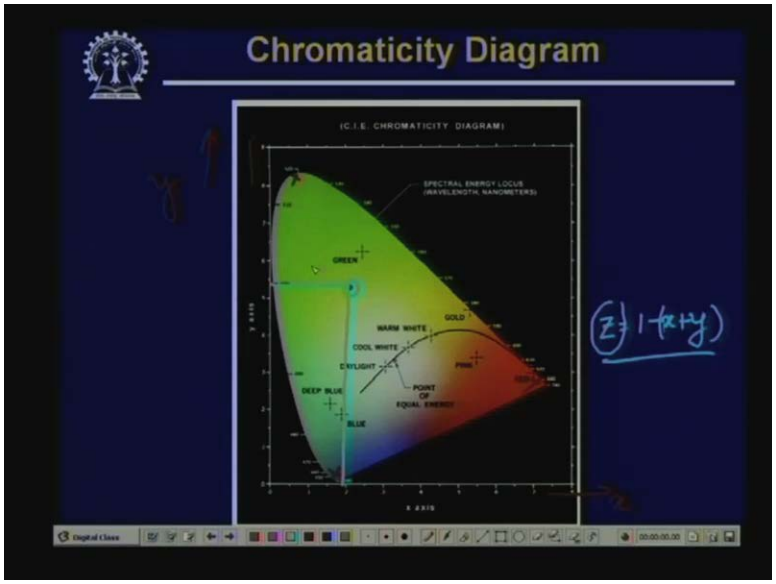

Chromaticity Diagram

Then, we have also seen what is the chromaticity diagram and we have seen the usefulness of the chromaticity diagram. So, the chromaticity diagram is useful mainly to identify that in which proportion different primary colours are to be mixed together to generate any colour. So, if I take 3 points in this chromaticity diagram; so one corresponding to green, one for the primary red and other for the primary blue, then given any point within this chromaticity diagram, I can find out that in which proportion red green and blue they are to be mixed.

So, here we find the horizontal axis tells the red component, the vertical axis gives us the green component and the blue component; so if I write this as x and this as y, then the green component z is given by 1 minus x plus x plus y. So, I can find out that how much of red, how much of green and how much of blue; these 3 components are to be mixed to generate a colour which is at this particular location in this chromaticity diagram.

It also tells us that what are all different possible shades of any of the pure colour which are available in the light spectrum that can be generated by mixing different amount of white light weight. So, you find that we have a point of equal energy that we have mentioned in the last class in this chromaticity diagram which is white as per CIE standard.

So, if I take any pure colour on the boundary of this chromaticity diagram and join this with this white point, then all the colour points all the colours along this line, they tell us that if I make different amount of white light to this pure colour, then what are the different shades of this colour that can be generated.

Then, we have started our discussion on the colour model and we have said that colour model is very very useful to specify any particular colour and we have said and we started our discussion on RGB colour model and we have discussed in our last class that RGB colour model is basically represented by a Cartesian co-ordinate system where the 3 primary colours of light that is red green and blue, they are represented along 3 Cartesian co-ordinate axis.

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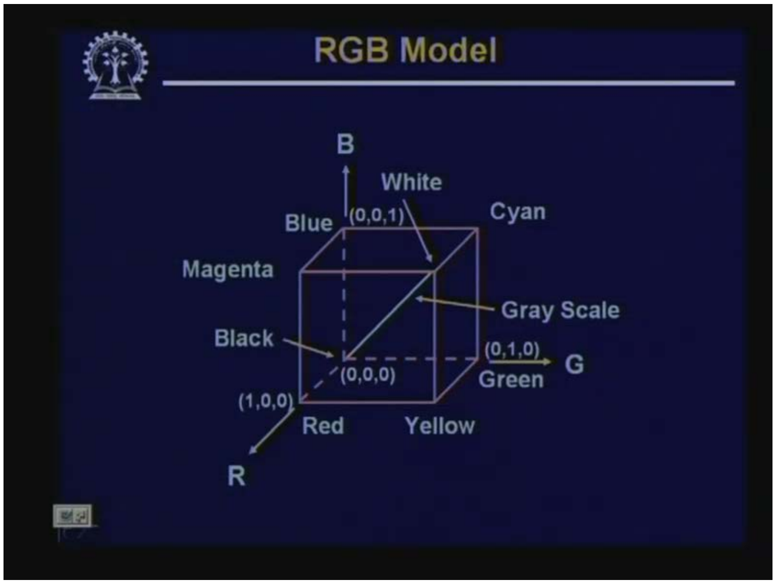

RGB Model

So, as per this diagram; we have this red axis, we have the green axis and we have the blue axis and in this Cartesian co-ordinate system, the colours space is represented by a unit cube. So, when i say it is unit that means the colours are represented in a normalized form. So, in this unit cube, we have found that at the centre of the cube, we have R, G and B. All these 3 components are equal to 0, so these points represent black.

Similarly, the farthest vertex from this black point or the origin or the red component is equal to 1, green component is equal to 1 and the blue component is equal to 1. That means all these 3 primary colours are mixed in equal proportion and this point represents white. The red colour is placed at location (1, 0, 0) where the red component is equal to 1, green component is equal to 0 and the blue component is also equal to 0.

Green is located at location (0, 1, 0) where both red and blue components are equal to 0 and the green component is equal to 1 and blue is located at the vertex location (0, 0, 1) where both red and green components are equal to 0 and blue component is equal to 1.

So, these are the locations red, green and blue that is (1, 0, 0) (0, 1, 0) and (0, 0, 1); these are the locations of 3 primary colours of light that is red, green and blue. And, you find that in this cube, we have also placed the secondary colours of light which are basically the primary colours of pigment that is cyan, magenta and yellow. So, these 3 colours – cyan, magenta and yellow, they are placed in other 3 corners other 3 vertices of this unit cube.

Now, find that from this diagram if I join this 2 points that is black at location (0, 0, 0) with white at location (1, 1, 1); then the line joining these 2 points - black and white, this represents what is called a gray scale. So, all the points on this particular line will have different gray shades, they will not exhibit any colour component.

Now, given any specific colour having some proportions of red, green and blue, that colour will be represented by a single point in this unit cube in a normalized form or we can also say that that colour will be represented by a vector where vector is drawn from the origin to the point representing that particular colour having a specific proportion of red, green and blue. So, this is what is the RGB colour model and you find that from this RGB colour model, we can also have the cyan, magenta yellow components by simple transformation. So, given any point in the RGB colour plain, what we can do is if I look at the different colour shades on different faces of this colour cube, you find that the shades will appear like this.

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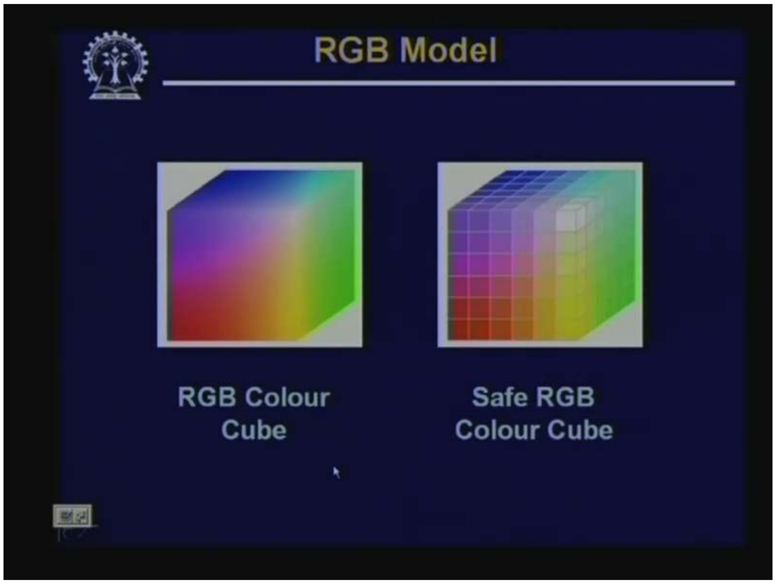

RGB Model

RGB Colour Cube

Safe RGB Colour Cube

So, in this colour cube, you find that we have said that the point (1, 0, 0) that represents red and you find that along the horizontal axis, the colour varies from red to yellow. Similarly, this is a point which is 0-0 which is (1, 1, 1); so this point represents white colour and in this particular case, all these colour component that is red, green and blue; each of these colour components are represented by 8 bit that means we have all together 24 different colour shades which can be generated in this particular colour model.

So, the total number of colours that can be generated is 2 to the power 24 and you can easily imagine that is huge number of colours which can be generated if we assign 8 bits to each of the colour components that is red, green and blue. But in most of the cases, what is useful is called safe RGB model. The safe RGB model, in safe RGB model, we do not consider all possible colours that mean all the 2 to the power of 24 different colours but rather, the number of different colours which are used in such cases is 216.

So, these 216 colours can be generated by having 6 different colours in red, 6 different colour shades in green and 6 different colour shades in blue. So, you find that on the right hand side, we have drawn a safe RGB colour cube. So here, you find that we have 6 different shades of any of the colours that is red, green and blue and using these 6 different shades, we can generate up to 2 to the power of 16 different colours and this 2 to the 216 different colours and these 216 different colours are known as safe RGB colours because they can be displayed in any type of colour monitor.

So, you should remember that in case of true RGB, though you can have total of 2 to the power 24 different colours but all the colour displays may not have the provision of displaying all the 2 to the power 24 colours but we can display 216 colours in almost all the colour displays. So, this is what is called safe RGB colour model and the corresponding cube is the safe RGB colour cube.

So, it is quite obvious from this discussion that any colour image will have 3 different colour components; one colour component for red, one colour component for green and one colour component for blue.

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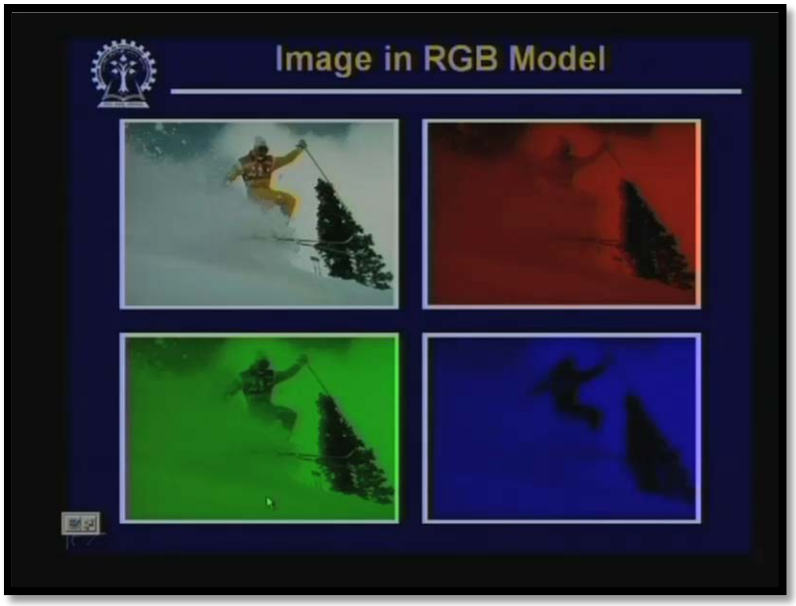

Image in RGB Model

So, if I take this particular colour image, you find that the top left image is a colour image and the other 3 are the 3 plains of it. So, the red colour component of this colour image is represented in red, the green colour component is represented in green and the blue colour component is represented in blue.

So here, you find that though we have represented these 3 different components in different colours that is red, green and blue but they are actually monochrome images and these monochrome images are black and white images and these black and white images are used to excite the corresponding phosphor dot on the colour screen.

So this, the red component will activate the red dot, the green component will activate the green dots and the blue component will activate the blue dots and when these 3 dots are activating activated together with different intensities, that gives you different colour sensation. So, obviously, for any type of colour image like this, we will have 3 different plains; one plain corresponding to the red component, the other plain corresponding to the green component and a plain corresponding to the blue component.

Now, as we said that this red, green and blue, they are mostly useful for the display purpose. But when it comes to colour printing, the model which is used is the CMY model or Cyan, Magenta and Yellow model. So, for the image colour image painting purpose, we have to talk about the CMY model. However, the CMY can be very easily generated from the RGB model.

So, as it is obvious from the colour cube, the RGB cube that we have drawn and the way the CYM - Cyan, Magenta and Yellow colours are placed at different vertices on that RGB cube, from there it is quite obvious that specified any colour in the RGB model, we can very easily convert that to CMY model.

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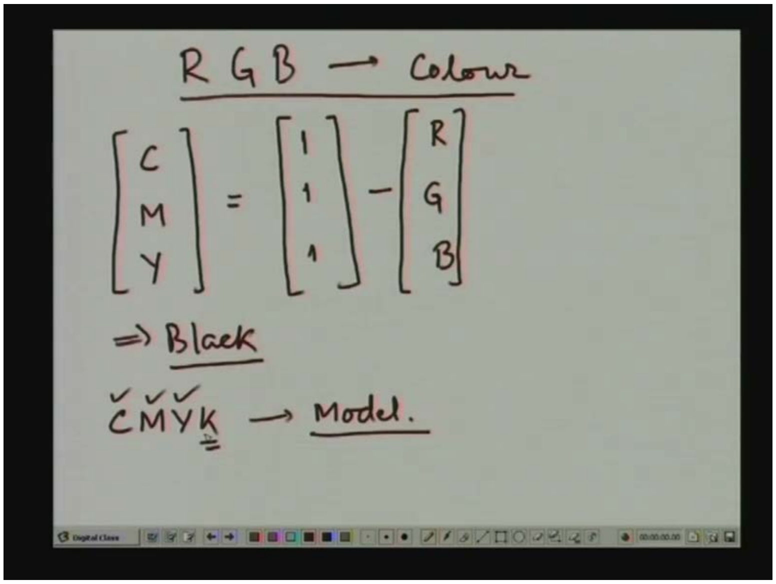

RGB → Colour

$$\begin{bmatrix}C\\M\\Y\end{bmatrix} = \begin{bmatrix}1\\1\\1\end{bmatrix} - \begin{bmatrix}R\\G\\B\end{bmatrix}$$

⇒ Black

$\overset{\checkmark}{C}\overset{\checkmark}{M}\overset{\checkmark}{Y}\underline{\underline{K}}$ → Model.

The conversion is simply like this that given RGB components; so we have the red, green and blue components of a particular colour and what we want to do is we want to convert this into CMY space and the conversion from RGB to CMY is very simple. What we have to is we have to simply make this conversion that CMY is equal to (1 1 1) minus RGB.

So here, you remember that these RGB components are represented in the normalized form and similarly by this expression, the CMY components that we get that will also be represented in normalized form and as we have said earlier that equal amounts of cyan, magenta and yellow should give us what is a black colour. So, if we mix cyan, magenta and yellow, these 3 pigments primaries in equal proportion, then I should then you should get the black colour.

But in practice, what we get is not a pure black but this generates a muddy black. So, to take care of this problem along with C, M and Y - cyan magenta and yellow, another component is also specified which is the black component and when we also specify the black component; in that case, we get another colour model which is the CMYK model.

So, the cyan, magenta and blue; so this is CMYK model, so cyan, magenta and yellow that is they are same as in CMY model. But we are specifying an additional colour which is black giving us the CMYK model.

So, you find that in case of CMYK model, we actually have 4 different components – cyan, magenta, yellow and black. If we are given the RGB, we can very easily convert that to CMY. Similarly, the reverse is also true. Given a specification, a colour in the CMY space; we can very easily convert that to a colour in the RGB space.

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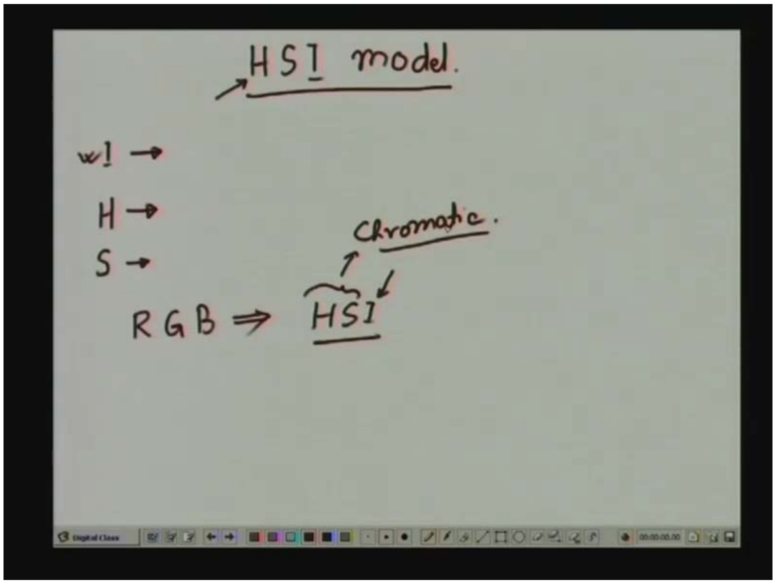

Now, the next colour model that we will consider is the HSI colour model that is hue saturation and intensity model. So, as we have mentioned in our last class that both RGB as well as CMY or CMYK, they are actually harder oriented. The RGB colour model is oriented towards the colour display or colour monitor. Similarly, CMY or CMYK, these 2 models are oriented towards 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 that particular colour. But what we really think of is what is 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 appear 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 motion 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 appear spectrum colour to dilute it and we have this component intensity which is actually a chromatic motion of the brightness. Now, the given the problem is given a colour in RGB space; can we convert that to HSI space?

Now, this HSI model has other importance also in addition to just interpretation by in addition to human interpretation because you find that this HSI 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 images or … images can be applied to this H to the images specified in HSI space. So, conversion of an image from the RGB space to HSI space is very very important.

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

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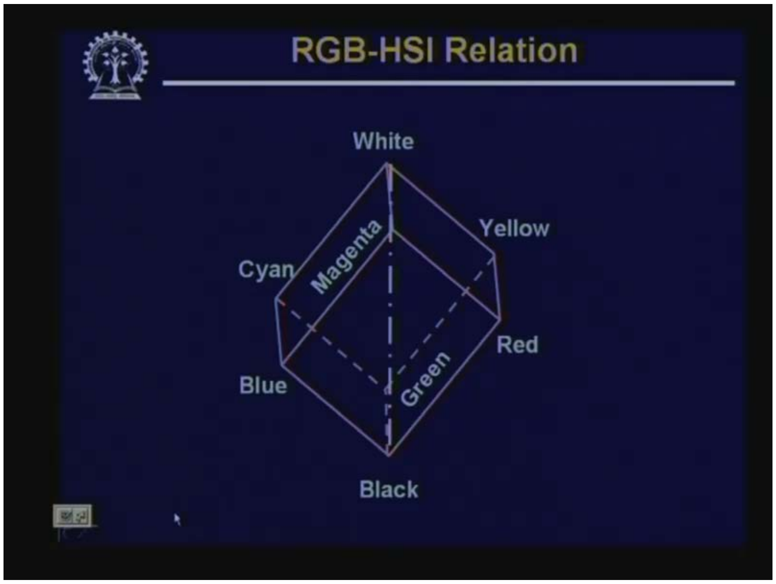

RGB-HSI Relation

So, you find that it is the same RGB cube and what we have done is we have simply reoriented this RGB 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. which so, any point on this particular line which joints black and white, they would not show any colour information but they will have different intensities or different gray shades.

Now, once we have once we reorient this RGB cube like this; now suppose we have a colour point, we have any colour point specified within this RGB cube, so I have this colour point specified in the RGB space. Now, for these colour point, now our aim is how we can convert this RGB specification into HSI specification.

So, as we said that the line joining black and white, this line is the intensity axis. So, in the HSI 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 a intensity component that is associated with this RGB 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. Now, 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 intensity associated with the RGB components specified for this particular point X. So, this is how we can compute the intensity 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, you can say that the saturation of all the RGB points, the saturation associated with all the RGB points lying on this intensity axis is equal to 0 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 from this intensity axis, these distance tells us that what is the saturation that is associated with the RGB components of point X. So, you can very easily compute the intensity and saturation corresponding to any RGB point given in the RGB space.

Now, the next question is 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. Now, for hue component computation, the concept is slightly more complicated.

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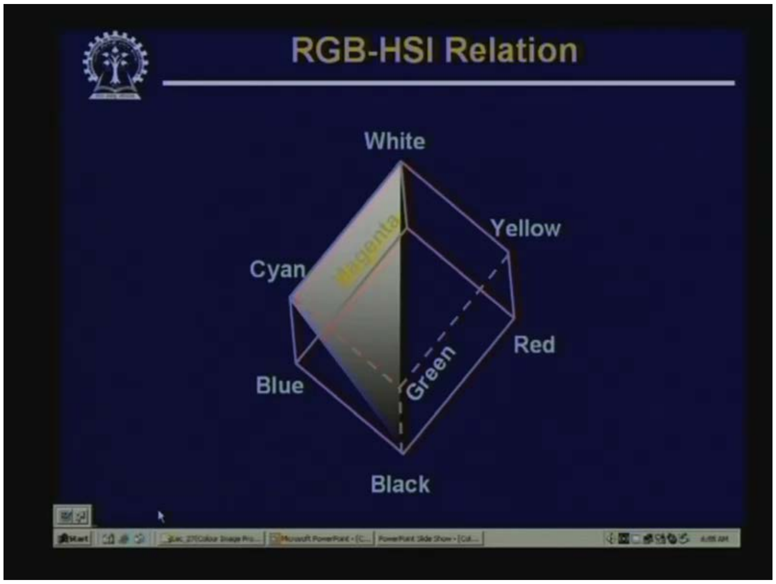

RGB-HSI Relation

Now, you find that in this diagram, we have shown a plan 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 0 and intensity at point white is maximum that is equal to 1 and the other point which defines this particular plane is the cyan that is this particular point.

Now, you will appreciate that for any points in this particular plane defined by these 3 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, you can also very easily verify that for any point given on this particular plane defined by these 3 points cyan, white and black for any points, the colour components can be specified by linear combination of these 3 points - cyan, white and black.

Now, because white is a balanced colour which contains all the primary components in equal proportion and black does not contain any color component; so these 2 points - white and black cannot contribute to the hue component associated with this point lying in this plane.

So, the only point which can contribute to the hue component is the cyan. So, for all the points lying in this plane, the hue will be same and it will be same as the hue associated with this point cyan. So, here you find that if I rotate this particular plane around this black and around the intensity axis by an angle of 360 degree, then I will trace all the possible points that can be specified in the RGB colours space. And by tracing, by rotating this plane by 360 degree around the intensity axis, I can generate all possible hues that can be all possible hues corresponding to every possible RGB point in the RGB colour cube.

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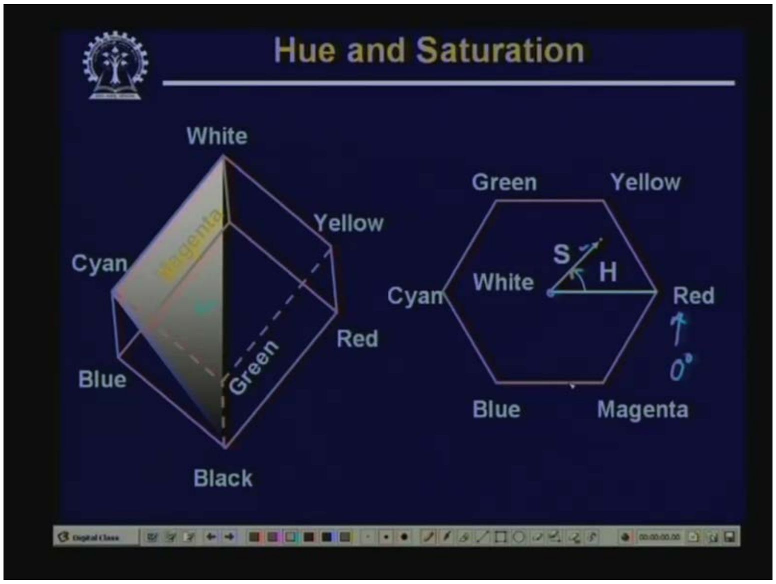

Hue and Saturation

Now, in order to do that what I do is like this; suppose, I take projection of this RGB cube on 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 2 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 colours of light and the primary colours of pigments, they will be projected at different vertices of the hexagon.

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

However, the angle of separation between red and yellow, this is equal to 60 degree. So, if I take the projection of the RGB 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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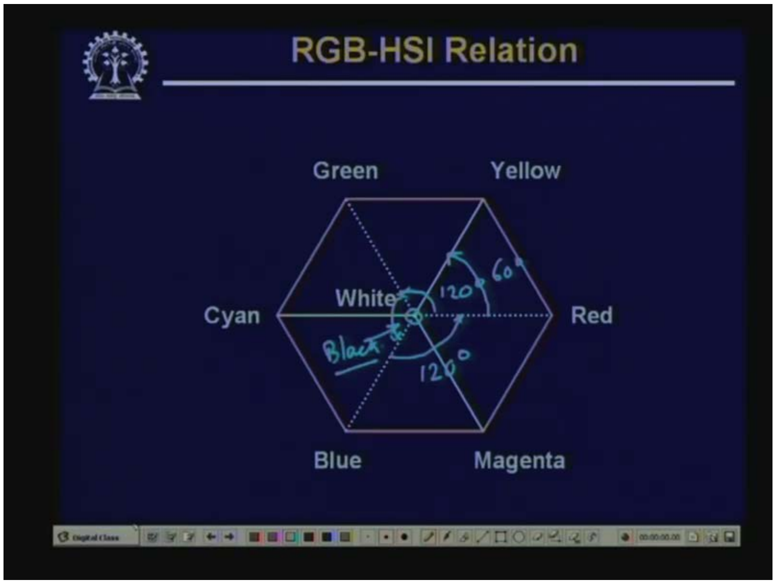

RGB-HSI Relation

Now, you will find that the projection of the shaded plane that we have seen in our pervious slide will be a straight line like this.

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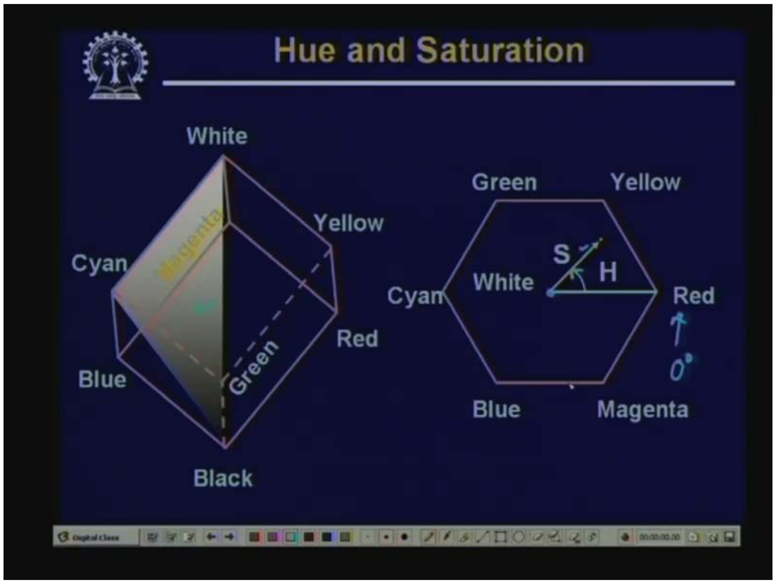

Hue and Saturation

So, for any point specified in the RGB colours space, there will be a corresponding point in our projected plane. Say, this is a plane corresponding to a color point in the RGB colors space and a plane on which this color point will lie, the plane defined by the corresponding color point, the black point and the white point on which this point will lie that will be projected as a straight line on this particular plane.

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 degree around the center of the hexagon. So, if I rotate this particular shaded plane by an angle of 360 degree around this black and white axis of the intensity axis; its projection onto the plane, onto 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 RGB color 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 colors and normally this primary color is taken to be red and this angle is normally is measured in anticlockwise direction. so that Using this particular convention, the red will have a hue which is given by 0 degree and as we rotate this shaded plane around this intensity axis, this particular straight line which is the projection of it will also be rotated by 360 degree and as it is rotated, the hue is going to be increased.

So, hue is normally measured 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 color specified in RGB 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 the B components.

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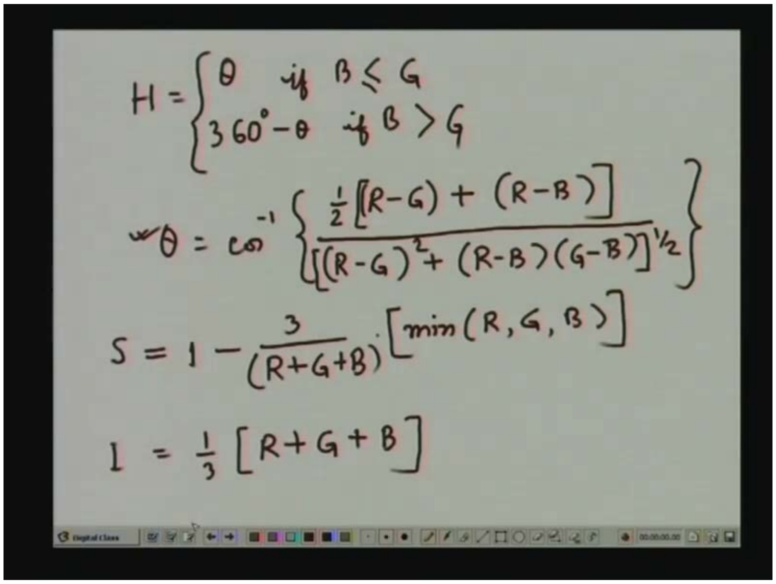

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360^\circ - \theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}\cdot[\min(R,G,B)]$$

$$I = \frac{1}{3}[R+G+B]$$

So here, the hue component; the H will be simply given by an angle theta and as we said that this theta is measured anticlockwise 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 component in the HIS in the HSI model where 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 into this to the power half where R is the red component, G is the green component and B is the blue component of the colours specified in the RGB space.

So from this R, G and B component, we can compute the value of theta following this expression and from this theta, you can find out the hue component in the HSI 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.

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 these red green and blue components, we can very easily find out the hue saturation and intensity components.

So, as we have converted from RGB space to the HIS space; similarly, you should also be convert any colour specified in HSI space into the components in the RGB space. So, to do that conversation or the inverse conversation, the corresponding expression can be found as you find that whenever we want to convert from HSI to RGB, then there are 3 regions of interest.

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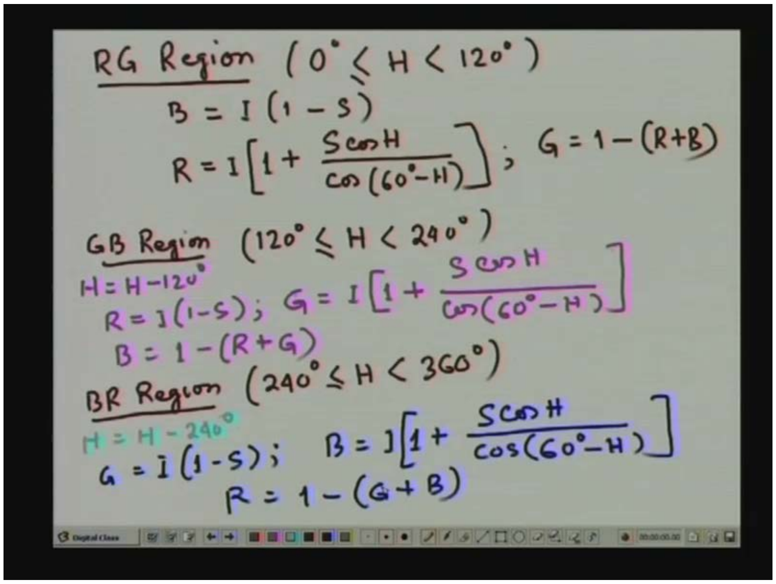

RG Region $(0^\circ \leq H < 120^\circ)$

$$B = I(1 - S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]; \quad G = 1 - (R + B)$$

GB Region $(120^\circ \leq H < 240^\circ)$

$$H = H - 120^\circ$$

$$R = I(1 - S); \quad G = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$B = 1 - (R + G)$$

BR Region $(240^\circ \leq H < 360^\circ)$

$$H = H - 240^\circ$$

$$G = I(1 - S); \quad B = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$R = 1 - (G + B)$$

One region is called RG region and in RG region, H lies between 0 degree and 120 degree. The other region is called GB region and in GB region, H lies between 120 degree and 240 degree and the third region is called BR region and in BR region, H lies between 240 degree and 360 degree. And, here in the RG region, you find that getting red, green and blue components is very easy is very easy. What I do is simply the blue component is given by I into 1 minus S where 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 GB 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 BR 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 obliviously, the R component is given by 1 minus G plus B.

So, we find that using these simple expressions, we can convert a colour specified in the RGB space to a colour in the to the colour components in the HSI space. Similarly, a colour specified in the HSI space can be easily converted to colour components in the RGB space.

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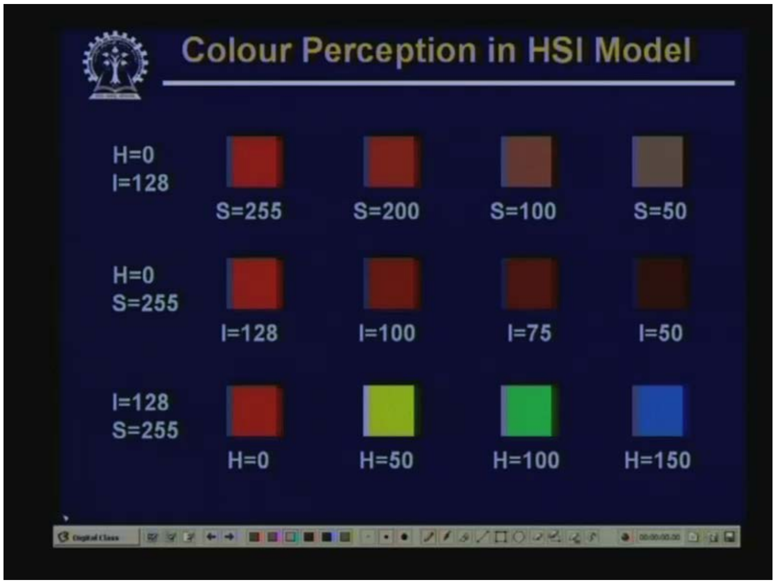

Colour Perception in HSI Model

So here, in this diagram we have shown the effects of this different components H, S and I on the colours. So, in the first row you find that the first rectangle S - a colour for which hue is equal to 0, intensity is equal to 128 and saturation S is equal to 255. So, as we said that our hue is measured from the red axis, from the red line; so hue equal to 0 indicates that it is red colour. In this case, the saturation 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, we will 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 S is equal to 50 where a large amount of white light has been added in this red component.

In the second row, what we have done is we have kept hue and saturation constant that is hue equal to 0 and saturation equal to 255 and what we have varied is the intensity component or the I component. So, here you find that as we decrease the I component, the different rectangles still show the red colour as we move from 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 that first row it appears that some white light has been mixed with the red whereas, in the second row there is no such appearance of mixing of white light but it is of the intensity which has been decreased. If you look at the third row, in the third row what we have done is we have kept the intensity and saturation constant but it is the hue component which has been changed.

So, we have started with hue equal to 0 which is red and here we really find that as we change the hue component, it is really the colour which gets changed unlike the previous 2 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, we are keeping the intensity and saturation same which is the hue component, it is the colour itself that gets able to changed.

So, here you find that when we have hue is equal to 100, it is in the green colour; when we have hue is equal to 150, it is the blue colour or else when hue is equal to 50, it is a colour between yellow and green. So, with these we have introduced the various colour models, we have introduced the RGB colours space, we have introduced the CMY or cyan, magenta and yellow colour space and also CMYK that is cyan, magenta, yellow and black colure space and we have also introduced the HSI 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 CMY the conversion is very easy, we can also convert from RGB to HSI but the conversion is slightly more complicated.

Now, with this introduction of the colour spaces, next what we will talk about is the colour image processing.

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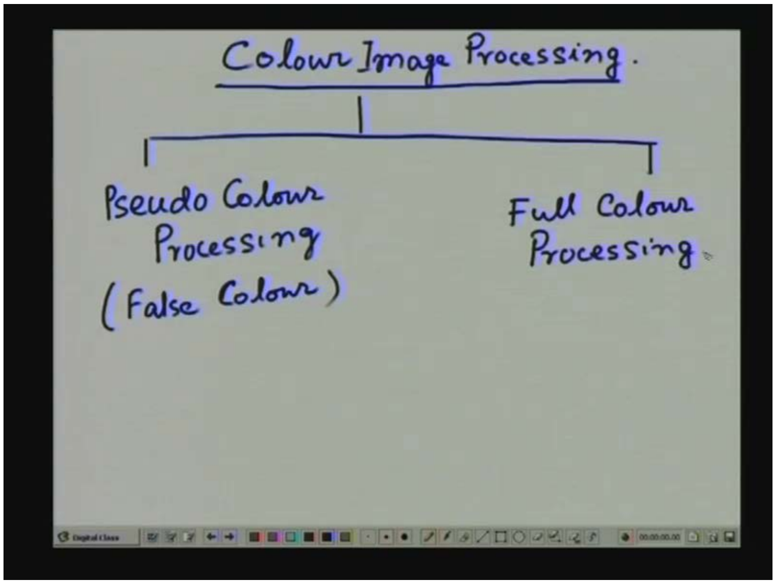

Colour Image Processing.

Pseudo Colour Processing (False Colour)

Full Colour Processing.

So far, what we have discussed is the representation of a colour or the representation when we take an image and take the colours component, the colours present in the image; then so far we have discussed how to represent those colours in either the RGB plane or CMY or CMYK space or the HSI space and images represented in any of these models can be processed. So, in colour image processing, we basically have 2 types of processing. One kind of processing is called pseudo colour processing, this is also sometimes known as false colour and the other kind of processing is what is called full colour 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 the 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 2 dozens of the gray shades whereas in colour, we can distinguish thousands of colour shades. So, given a grayscale image or a simply black and white image, if we can assign different colours to different ranges of gray values, then the interpretation of different ranges of gray values is much more easier in this pseudo colour images than in the grayscales images.

So, we will discuss about how we can go for pseudo-colouring of an image given in the pseudo-colouring of a black and white image. So, as we said that this coloring has to be done following some criteria. So, with this introduction and of course, in case of full colour processing as the name indicates, the images are represented in the full colour and the processing will also be used, processing will also be done in the full colour domain.

So, given this introduction of the colour processing techniques, the 2 types of the colour processing, pseudo colour processing and full colour image processing; we finish our lecture today and we will continue with this topic in our next class. Now, let us come to some questions on today's lecture.

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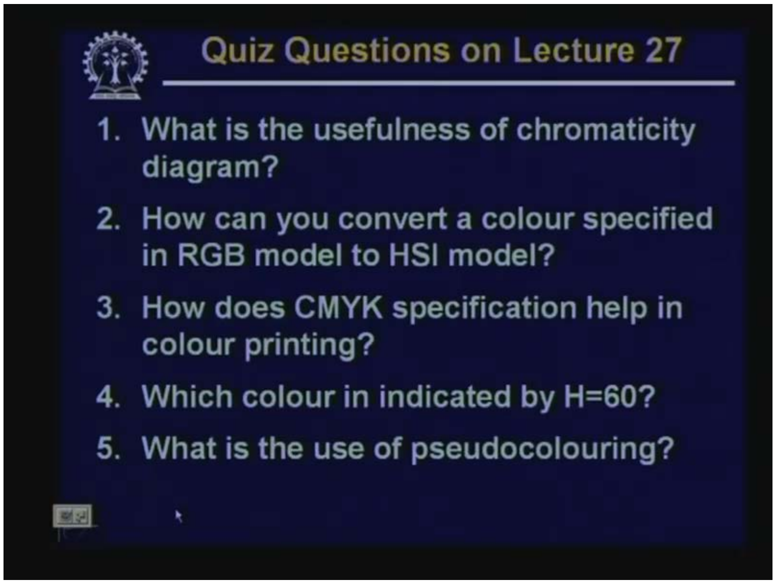

Quiz Questions on Lecture 27

1. What is the usefulness of chromaticity diagram?
2. How can you convert a colour specified in RGB model to HSI model?
3. How does CMYK specification help in colour printing?
4. Which colour in indicated by H=60?
5. What is the use of pseudocolouring?

The first question is what is the usefulness of chromaticity diagram? How can you convert a colour specified in RGB model to HSI model? Third question, how does CMYK specification help in colour printing? The forth question, which colour is indicated by H is equal to 60 that is hue is equal to 60 and the fifth question, what is the use of pseudo colouring techniques?

Thank you.