INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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Digital Image Processing of Remote Sensing Data

Lecture – 06
Color Representation and Transformations

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Welcome everyone and welcome to this 6th lecture on this digital images processing of remote sensing data and in this particular discussion we will focus mainly color representations and transformations but before I proceed this is very interesting that basically color do not matter though I am making a little bold statement a color do not matter in really in remote sensing what matters the pixel value digital number of an image but in order to represent or in order to displace images are get there print outs we use colors.

And therefore colors become equally important in digital images processing as well as remote sensing also we explode the fundamental properties of colors there combinations primary colors additive color, secondary colors four different types of four different purposes as we know that primary colors we use while displaying something on computer screen or may be through the projection systems and other things.

Whereas the secondary colors like cyan, magenta, yellow and black we use for printing device so there are various applications of this however digital images processing we can explode various aspects of colors and can perform color transformation and explode it the images of different special resolutions and different bundle images and it can merge or fuse the images, so in this particular discussion we are going to see all these things in much more detail as we know the 3 there are various characters the 3 important characteristics of colors are hue.

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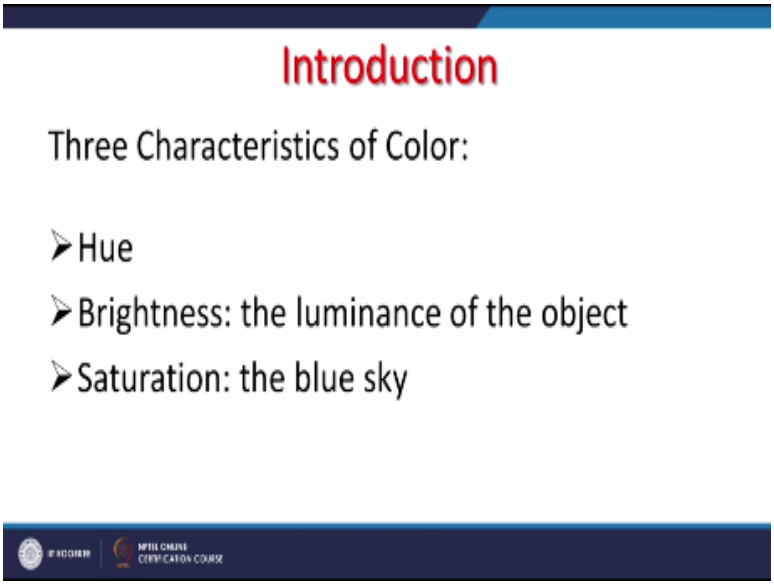

That is the basically color then brightness also we call that the luminance of the object and then the 3rd one I the saturation the like for example blue sky so these 3 characters are very important also from 1 later on I will be showing one color cube in which we can perform transformations from 1 plane of colors to another and there these fundamental characteristics say hue brightness and saturation will play major roles.

So these are the important things to remember now in the previous lecture I have discussed in detail about the disable of EM spectrum and this is how different colors will respond so in the lower wave lengths that we call as blue spectrum.

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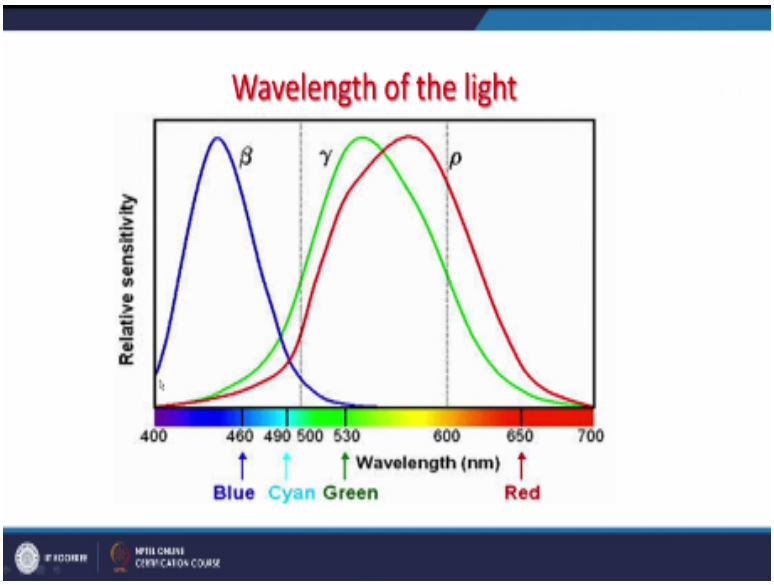

As we can see here that here the blue will have the maximum reflection where as in the green part of this thing we will have but seen in the cyan part hardly any reelection but then in the later part of EM spectrum that means towards the longer wave lengths now we are getting the red color so all these 3 primary colors blue, green and red are present and there reflectivity in relative sensitivity here is plotted is exported in digital images processing extensible. This is the color cube which I have just motioned few seconds before in the far behind there is a.

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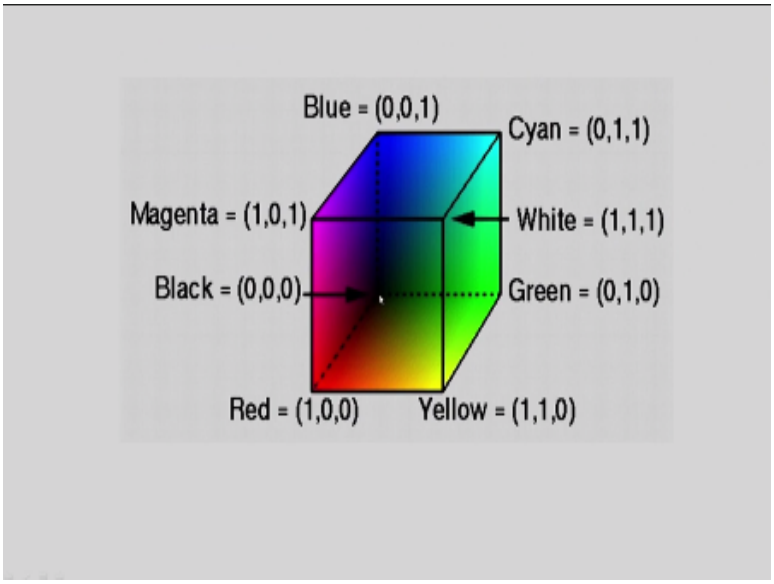

The corner this which for the in this demonstration we assign a black color an all values we keep here 000 so you say 3 because it is a 3 dimensional so there are 3 axis are there and that is why there are 3 values have been so when all values that means if I think red, green and blue in that sense then when all values red, green and blues are 0 then we get the black color and when all values in this here the scale is between 0 to white when all values are 1 all these 3 axis red, green and blue then white.

And this is what is shown here the red axis is here the blue axis is here and the green axis is here and like in case of red axis the it is the extreme and her so one is 0 the first one is red and then second one is green 3rd one is blue and both of these two color component or roles of these two color art this corner are 0 no role is there the similarly for green where as the red is 0 green is one the maximum and then blue I 0 where as in case of blue 0, 0, 1 and then secondary colors which is the cyan color will occupy the other remaining corners of this cube.

So 2 corners have been consumed by black and white other 3 corners have been consumed by red, blue and green now 3 more corners of this cube, cube left that is one is cyan so there sign and cyan is the secondary color and therefore it is made from blue and green so these two are playing very important role I mean they are having the full strength then you get the cyan in case of magenta color you get only red and blue and green is 0 and it is the secondary color so it is formed here and located in this representation on this corner.

And the 3rd one is the yellow which is 1, 1, 0 that means it is having red color component it is having green component and no blue component what is over and it makes the so all primary three all three primary colors all three secondary colors and 2 extreme colors which makes a gray scale or located here on all 8 different corners so if you assume a line I mean black to white diagonally this axis then the gray image will be formed if we exploded that one.

But if we exploded more than 2 colors then there is he going to be if a plane which will touch all these 3 corners and the image will be projected on it so the for understanding of colors and color transformation is basically understanding of this cube which is very simple one as to be in real sense and very much required, now if we take out a corn out of solid corn out of this cube and which is shown here.

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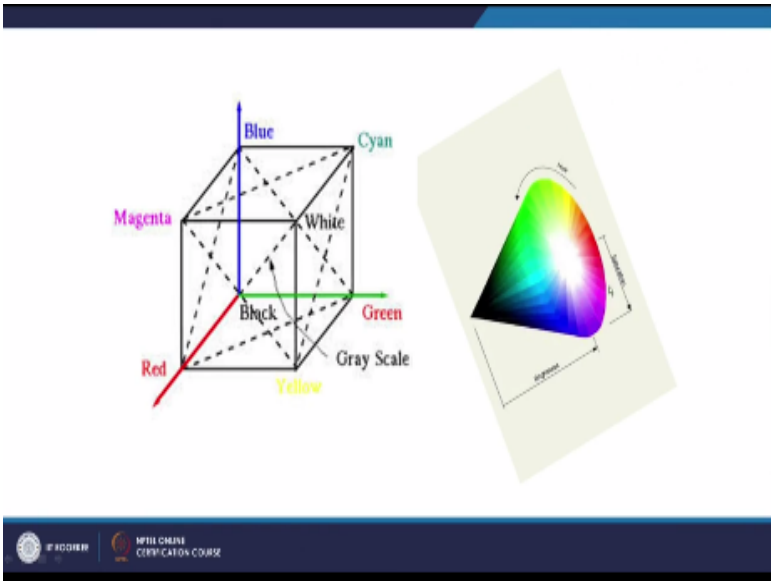

Then on the base of this cone all colors all seven colors will be present her and that is we call as hue and the brightness because the black is the darkest white is the brightest so the brightness will be represented by axis which is nothing but the height of this corn so that why here it is black shown white is shown and then saturation is about these individual you know flax which are shown here that make so in the inside you do not have saturation but as go towards the corner of this color cube the saturation increases.

And at the extreme corners that it reaches to the maximum no other colors in case of primary colors play any role where as in case of secondary colors only two main colors will play major

role so after understanding this 3D cube of colors space now we I have taken out as a corn and understanding of this corn will make our understand much better about the color space and particularly the transformation which we are going to talk little later. So as we know that color space which these 3 desks been shown since childhood but very briefly I will go through that.

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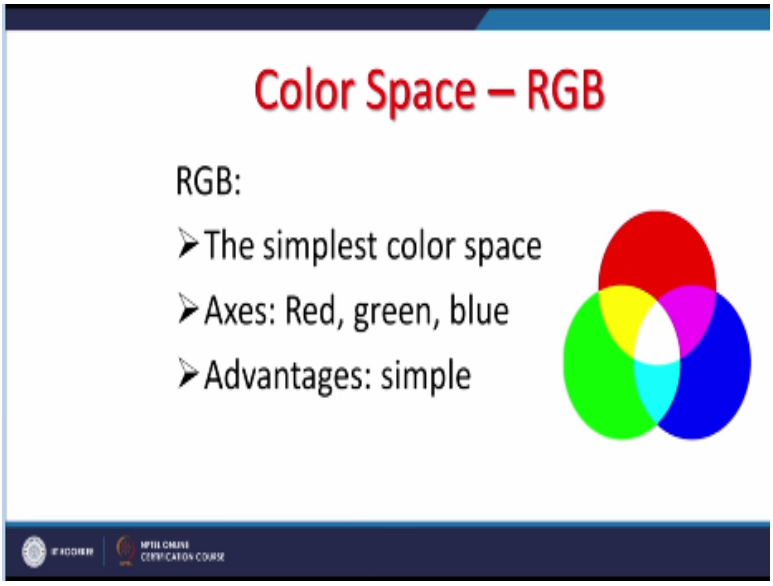

The simplest color spec which was told to us the axes or the corners of color cube are red, green, blue advantages it is simple and these are also primary one.

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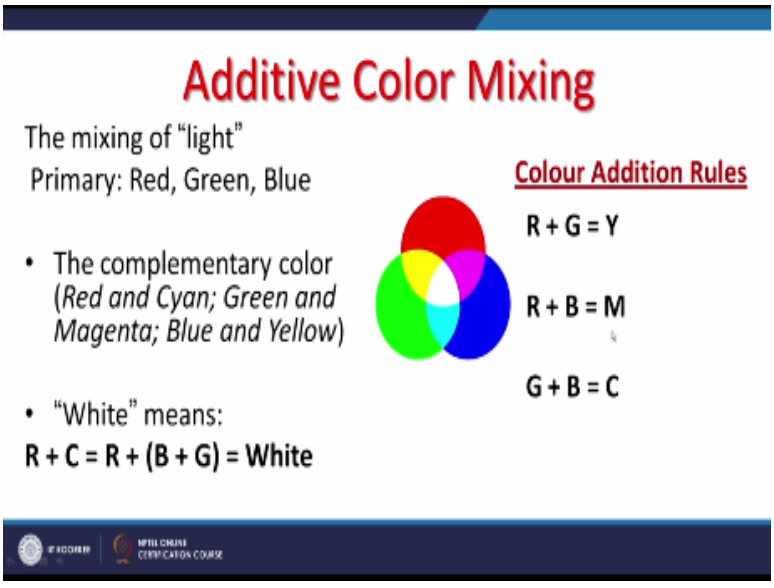

Now when we go for mixing of colors then the primary colors are red, green, blue and when you mix like red and green you get yellow when you mix a red and blue you get the cyan or magenta and then you get the cyan as well so the complementary colors are red and cyan, green and magenta, blue and that thing and when these all colors are getting mixed then you are getting the white color.

So this is what white color can also be defined then the red and cyan you add the red + B + green and then it makes white so here you can see that the red color then the cyan color is there cyan color is here and then red again you mix with blue and green, blue and green that make the white one. The color additions are also exploded in digital images processing especially in color transformation like when we add R and red means red and green we get yellow and red and blue we get magenta and green and blue we get cyan.

Very interestingly when we go for saturator pheromatrophy processing using the radar data there the fringes will also be generated and which are also in these colors and there we count the fringes in order to estimate the deformations so the colors are also become very important even in case of saturator pheromatrophy or radar remote sensing or microwave remote sensing, so colors are not only important in case of visible or infrared but also in radar remote sensing, so both active and passive remote sensing and processing that means digital image processing or these data sets colors play very, very important role. Now let us discuss little bit about the subtractive color mixing that is it is also we say pigment because these are the colors which you use for printing.

So these are the primary color say in this one though we call them subtractive and this subtractive color scheme we call them as primary but in normal understanding we say the secondary colors cyan, magenta, yellow because they are made from.

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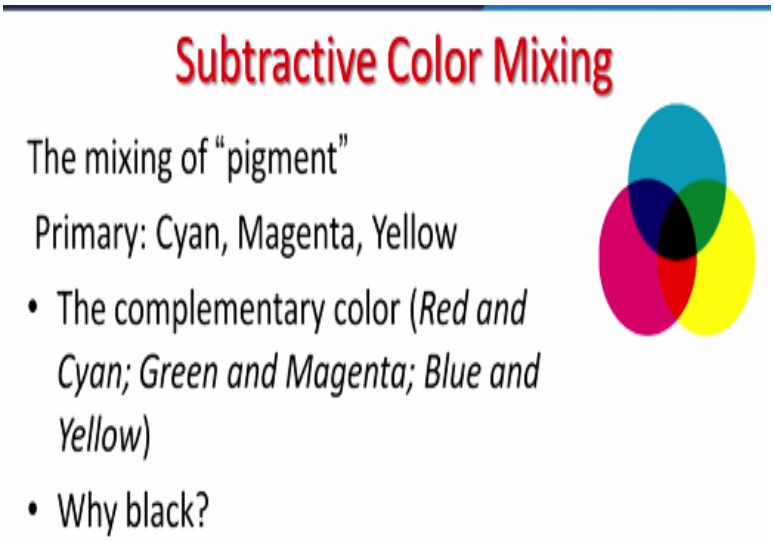

Two other primary colors whereas primary colors cannot be made from these things or more closes colors can be generated so the complementary colors like red and cyan, green and magenta and blue and yellow all these are only here and again when you mix all these like in case of additive color scheme you get white in the center here you get the black in the centre.

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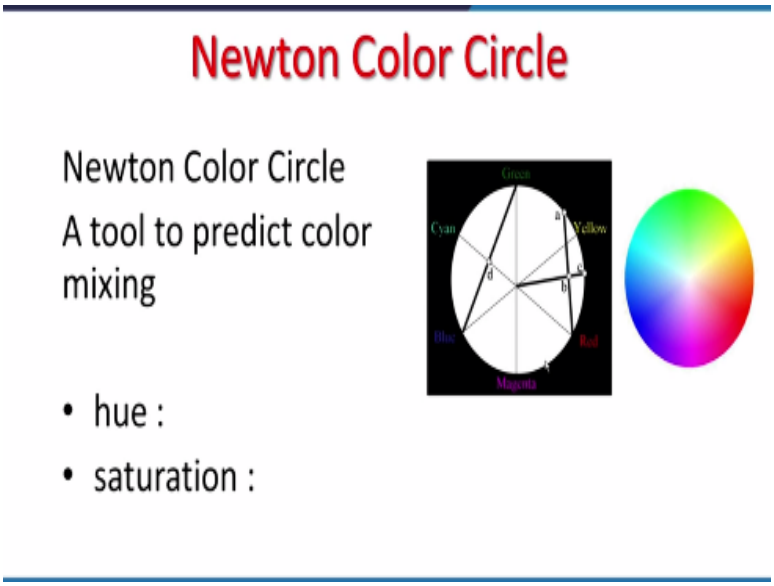

There are other ways of representing color space and one way is that Newton color circle you might remember in Newton disk which was in our 7th, 8th class physics or science practical's

which was when this disk is rotated at relatively a higher speed we see white color, in order to demonstrate that it is made all white color is made from these 7 colors, so that is why the one way of representing or predicting the color missing is using this say concept now hue, saturation and your brightness they are very, very important here.

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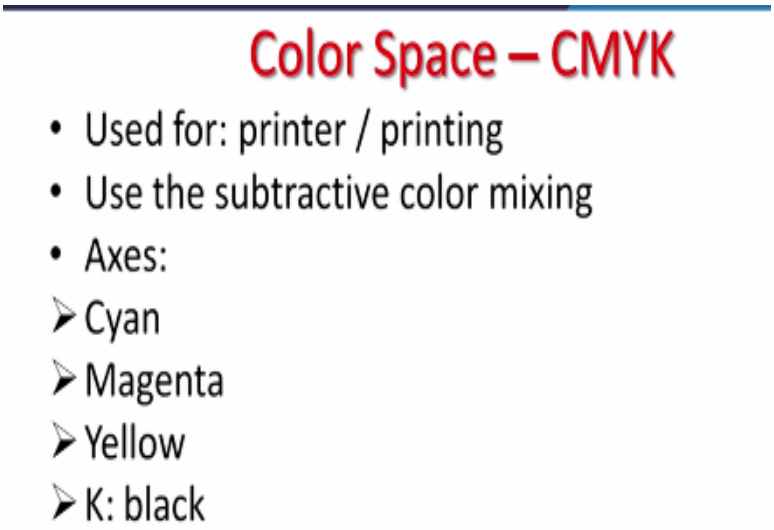

So that is why this CMYK that is cyan, magenta, yellow and black are there as I have already mentioned these are used for printing and these are the subtracted color mixing there are axes are important the three axes are there cyan, magenta, yellow and black is also used so that we do not have to mix all these three in order to create black saves the resources, the color space from we can convert what I mean is, that if you are having a color image.

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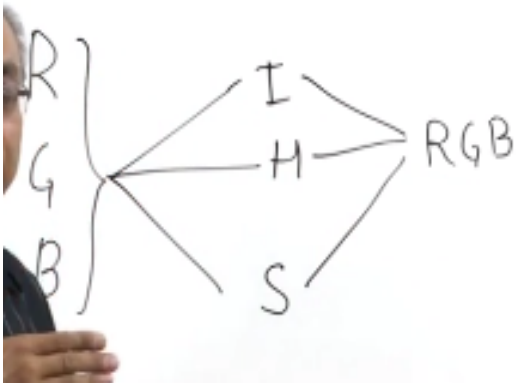

If you are having a color image which is made from RGB three colors Red, green, blue you can split that into three other color components as I have been mentioning that intensity or you can call as brightness, hue and saturation. So this is splitting and inverse or backward transformation is also possible so we can also transform back to RGB spaces that means we are basically changing the plane within a cube.

And within that color space as I have discussed in the beginning, so this is very important and that convergence are possible and we do not when we go for a color transformation in digital image processing. So you can generate different colors using these kind of a simple equations and like black also minimum C, minimum M.

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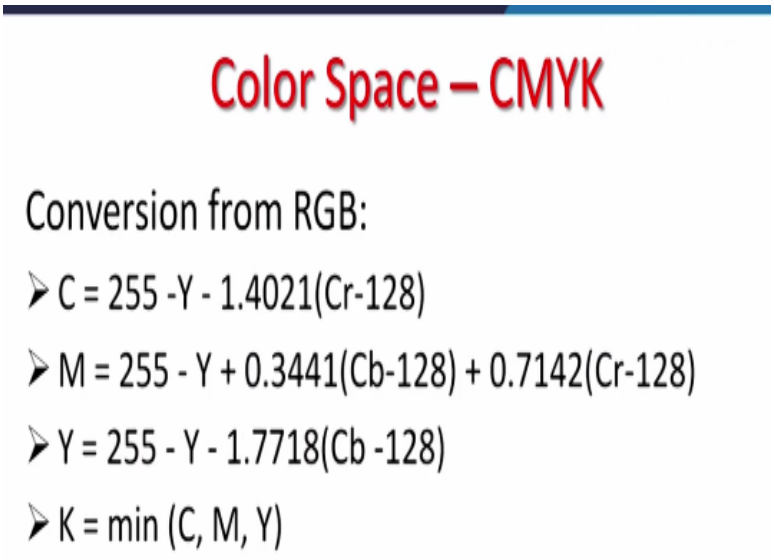

And minimum Y.

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Color Space – Comparison

Color space	Color mixing	Primary parameters	Used for	Pros and cons
RGB	Additive	Red, Green, Blue		Easy but wasting bandwidth
CMYK	Subtractive	Cyan, Magenta, Yellow, Black	Printer	Works in pigment mixing

You can get these color, now if we compare between these two major skews one is primary secondary or additive or subtractive color scheme like RGB additive color scheme, primary parameter are red, green, blue and use for of course display and then easy but not wasting bandwidth here, whereas CMYK is subtractive color scheme the members are parameter are cyan, magenta, yellow and black mainly used for printing. Here it is used for display and working in the pigment or mixing and printing as well.

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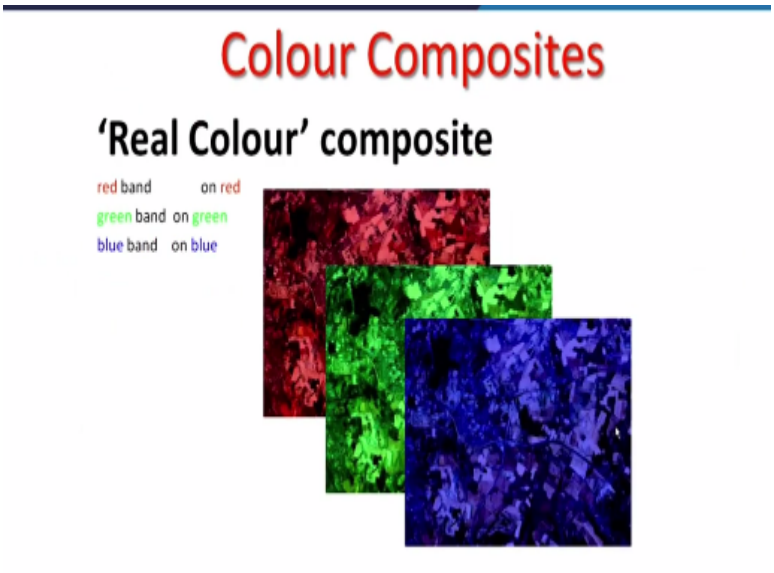

Now let us come to the real color transformation kind of thing but before that color composites, one color composite we are now familiar with the false color composites where we assign different color channels two different bands and ultimately we and upto the RGB color an image which it false in the RGB color space that means a plane which will touch all these three corners, so your image will be projected on that.

So RED band in if we are approaching for instead of false color if we approach for the real color or near real color I also told in previous classes that using satellite data it is near impossible to create a true color image what we see through aircrafts and the same color image we can generate through mixing of colors or this thing, so whatever the we even mention a real color composite it is near real color it is not truly color.

Because we will be explaining infrared and we know that why in visible light or our eyes or not sensitive so when what we see through aircrafts that kind of image cannot be seen through the satellite images by mixing of any kind of bands anyway so the red band on red when we assign red band that red band that part of later part of EM spectrum in the visible section so that part has discuss earlier is called red band then green band on green and blue and all this simple color composition and that makes the real color composition that is possible when you are having narrow bands and learn relatively more number of bands so in case of lenses dimensions such a composites are not possible but in case of well I see in like land set or in other case when we will have the hyper spectral the probably all these things are possible. So narrow bands are required

more number of bands are required in order to create near real color composites and this is the output from that one.

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That red band on red, green and green, blue and blue and this is what you see here. Near real color composite image but generally for better interpretation we prefer false color composite because vegetation here is coming quite dark and therefore it becomes very difficult not really in green in true color images or near color real color images the vegetation should cover green but it is not and there the chlorophyll content is reflected.

Differently in infrared channels so there distinction will be in various objects including vegetation becomes much easier in false color then real color but still for some certain applications may be real color or true color images or composites might be required, one other possibility is.

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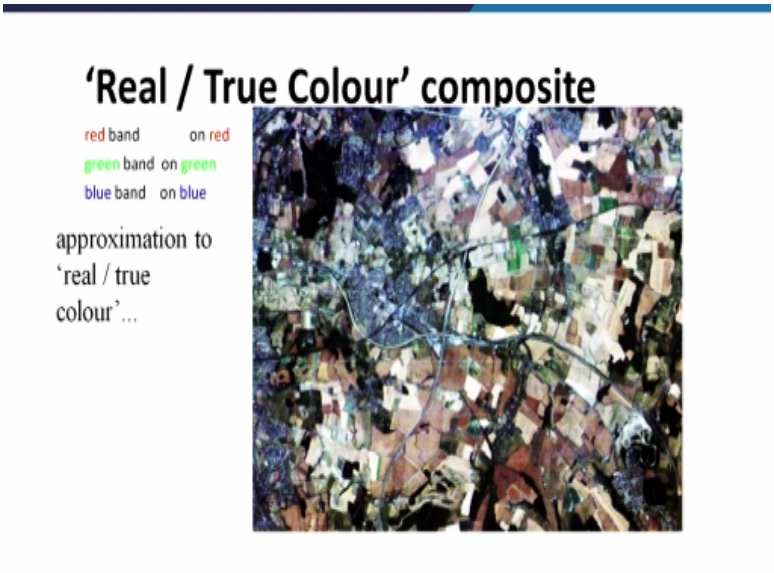

Red band on red and green band on green, blue is so that you may end up a different kind of representation or a color composite.

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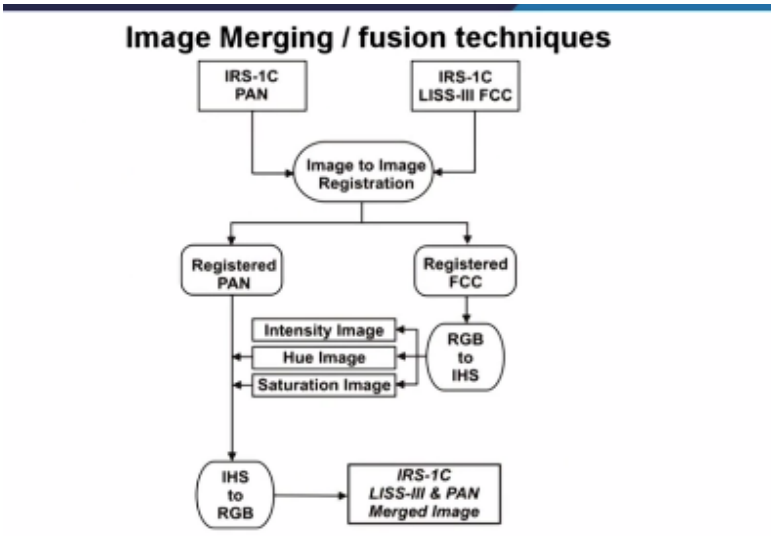

Image fusion / merged process

Now let us come to the color transformation and I will show you the real how it is done and that if you are having images two sets of images one has come like panchromatic or black and white image and might be having higher spatial resolution and there might be another image another sensor which might be providing multi spectral images but at lower space resolution and the example is shown here in this flow chart.

That in the real example what we have done we have taken IRS-1C PAN data which is a panchromatic black and white data here and IRS-1C LISS 111 which is false color or a similarity spectral data, so the spatial resolution here is in case of IRS-1C PAN is 5.6m whereas the in case of LISS 111 the spatial resolution is 23m, so how color space can be exploited to create a new product which is merged or fuse product.

Fuse product in sense that in this output image will exploit both the best of spatial resolution in best of spectral resolution that means it will have a IRS spatial resolution but in colors, whereas separately here we are having IRS spatial resolution but in black and white here we are having multi spectral or colored image but lower spacial resolution, the output will have both advantages of both.

How we achieve very simple way of doing this thing that first image tree image registration is required in later sections of this course we will be discussing the geo-referencing section which is a very a common technique even in GIS as well as in remote sensing digital image processing, so very much required so first is image to image registration that means that PAN image and the LISS 11 image should fit or they stuck together very nicely.

If the there is a mismatch then the output will not be very sharp, so all of those some people get the PAN sharp images for fused images or merge images they also called pen sharp images, pen sharp means they are exploiting the IRS spatial resolution data which is available with panchromatic sensor and using and mixing or merging that data with multi spectral data which is having a relatively low spatial resolution.

So first step in this image to image registration then this registered PAN image continued here whereas the registered color composite or false color composite is splitter into three components. red, green that plain is projected to HIS as also mentioned here and then this splitting is done now three channels initially you had red green blue you have create a new three channels which is intensity human saturation, remember that days of that further cone which we look out through the that 3D cube as well, now here this intensity may huge image and saturation image so after a splitting RGB to HIS.

We get three images intensity huge and saturation the pan images which is already now registered, pan we which is having higher space resolution they replaced with the intensity image because this is still carrying low resolution that is in this example 23.5m resolution so we drop this one therefore there is no continuity and we continue with the pan, pan image of higher resolution and then we go for reverse transformation or backward transformation that means again from HIS plane to RGB plane and after once we perform this then we get and output which is having higher special resolution.

Generally here and same time it is having the colors which are coming from multi spectral data so two sends us data in this case these were both on the same satellite but one can explained I will be showing an example where one map and one satellite image, can also we merged can also we fused and you can create any product, so plain with colors in digital image processing is very, very important though in the beginning I said if we start looking individual brand of image then colors will not have any meaning because the pixel values carriers but here we are putting them into color space brining them into color a space, and trying to explained and the color with the color cube and the cone and for our room when if it is so, let us see the real example as I have been mentioning this is cone and a little bit different it is explained and shown here, that one hand you are having red.

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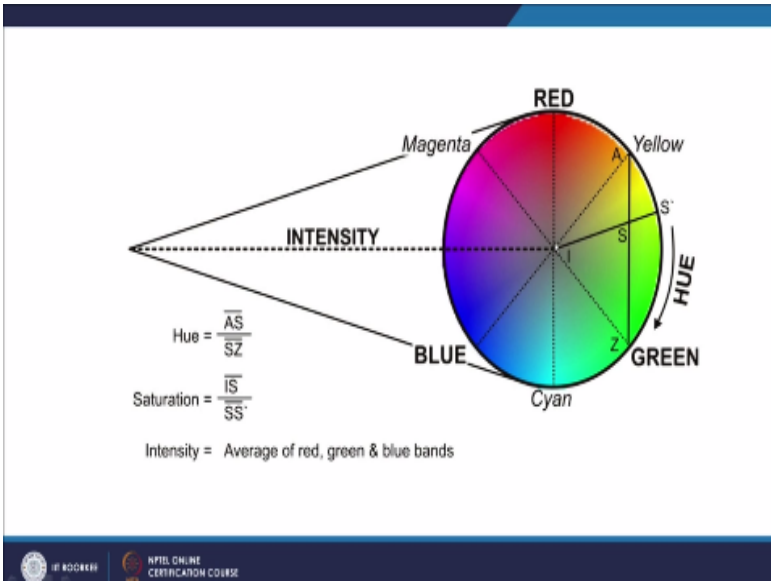

On the circle which is nothing but the base of the cone that you know the effects of the cone is here and here you will have the highest intensity here you will have the lowest intensity opposite to red you will have sign cyan color if you opposite to green you are having magneta color and opposite to blue you are having yellow color, so this say radius is nothing but the saturation the perimeter showing the colors or here we call them, and intensity axis yes black to white which is here from the base of the cone.

Center of the base of the cone to the effects of the cone and this is how we explained this one, now the real example is I have been mentioning.

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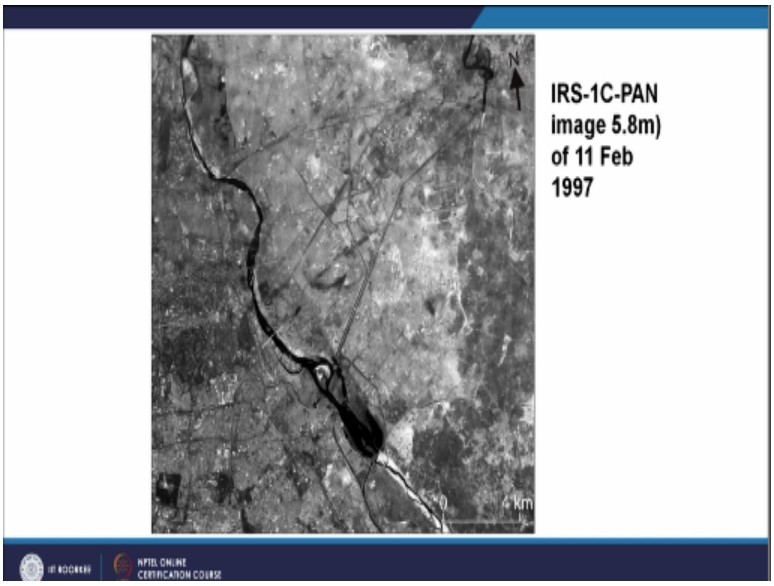

Higher raise 1C PAN 5.8m resolution taken of 11 February 1997 and this area is part of NCR region daily region you see here very sharp image but it is in black and white.

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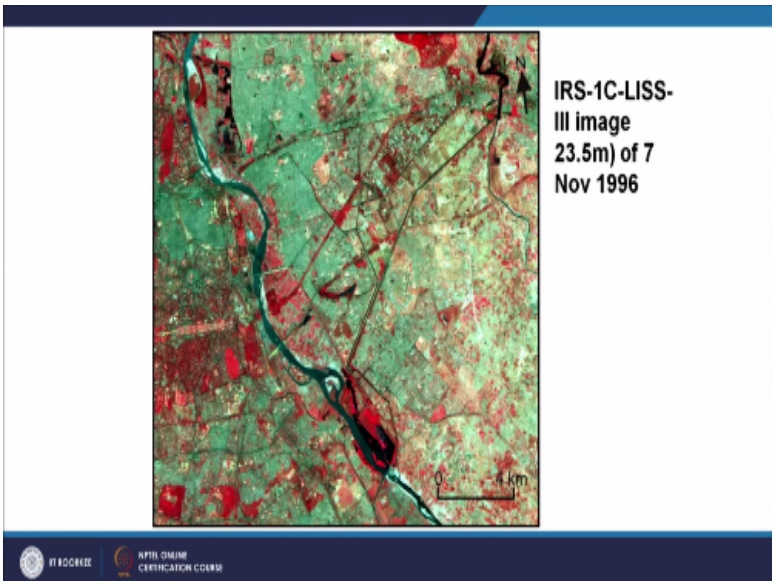

Whereas you see a colored image or falls color image from LISS III IRS LISS image we say 23.5m but not a sharp, yes here note a sharp the PAN is this LISS three, so it is having one quality and LISS three is having one quality that it is in colors and whereas and the PAN though it is in black and white but it is sharp it is having higher space resolution so the main purpose here is to use the best quality of both and create any product and this is how the product looks which is now at 5.8m resolution.

And colors as well so simple PAN image did not have the colors and your LISS three did not have the resolution but I had the colors whereas this merge image or fused image or PAN sharp image is having both it is having color and higher special resolution, so just exploiting the color space plain little within the digital image processing with the digital image processing software's we can create new products, and this is what people have been doing now these products I will show you some June daria of all three images together that here this is the LISS three image.

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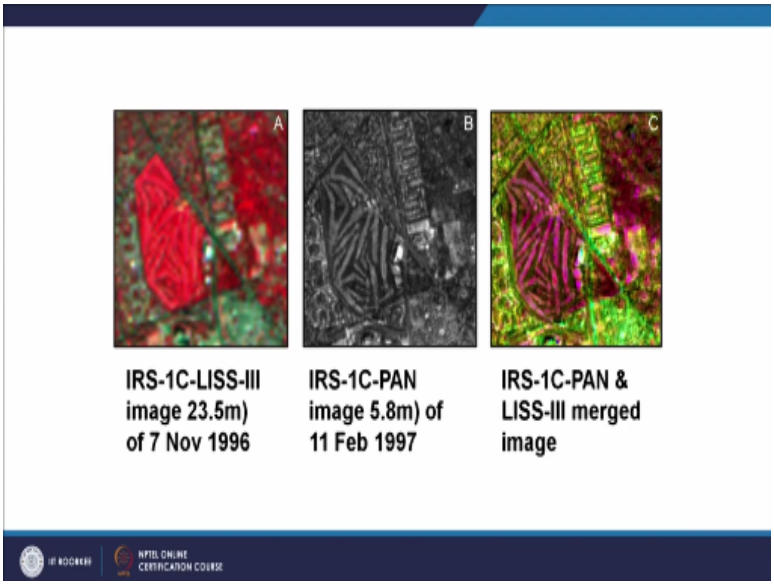

This is PAN image higher special resolution lower space resolution but this is multi spectral this panchromatic the best quality of both is exploited and this is what you see, though the colors in typical falls color composites are not appearing in the image C which is PAN so or merged but the see the distinction and this is the daily call course area where individual these wholes can we identified very easily as compared to black and white image or even falls color image having relatively lower special resolution.

So this is what how the merging can be done exploiting color a space now I let me take another example where in this case one colored map bus used the purpose was little different here but the same color space bars exploited little differently and that is this is what the beauty here is like this that.

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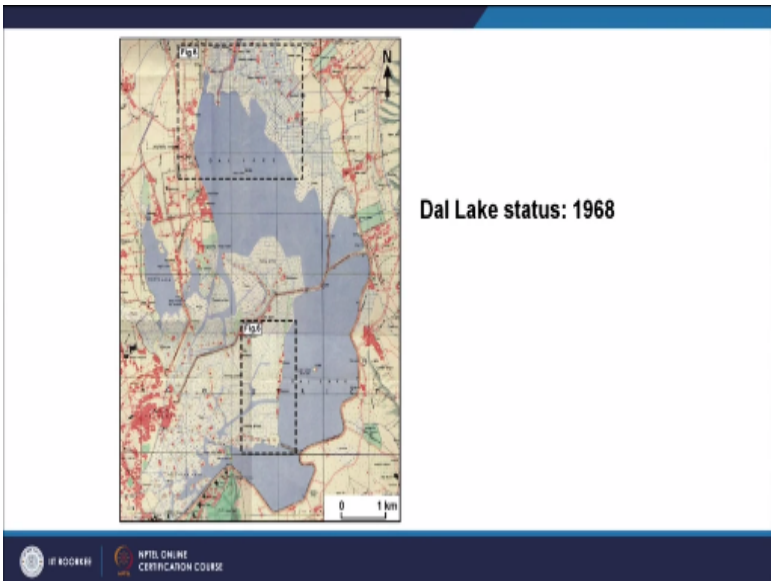

This was a print as you can see even the folding sees which we are receiving here, so this was a print but in color so this was the scanned and then once you scan an image or a map which is colored map then you get a basically color image then you can handle acid colored image so we I handled that one as a colored image and we had.

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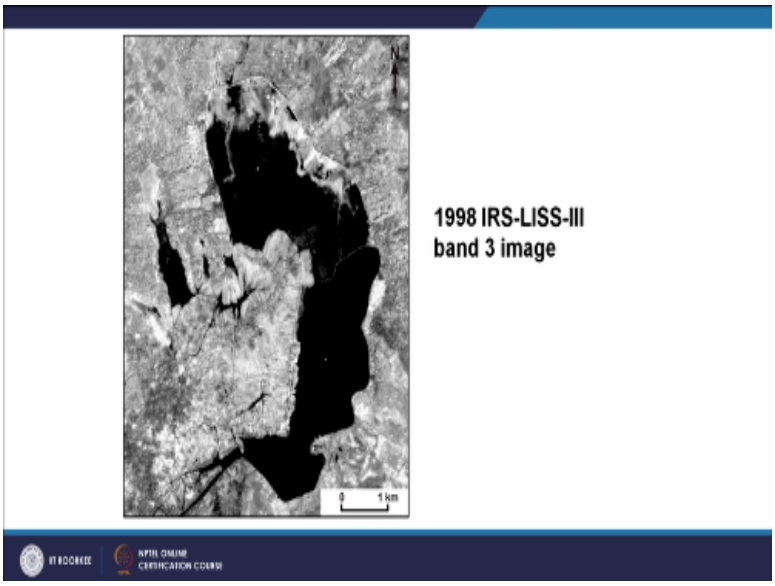

A very high relatively higher resolution and data LISS three band three especially that because the target was to see the vegetation and when three is the near infrared, infrared part of EM spectrum for the LISS III sensors so the main purpose to see the water OD as well as vegetation so space you the band three we was choose any here, though LISS III color composites can be made but here now we are doing the little different leave that we are using colors here and also this Dal lake map.

Which is a survey of India map at either large scale and but it is age by is your date when it was survey was in 1968, but in this is in 1998, so 30 years time difference so here instead of like in previous example here now we want to see how things have changes around the lake specially in the lake body the water body between these 30 years and this is how we exploited that this is the output from that and this is the black and white representation on the map.

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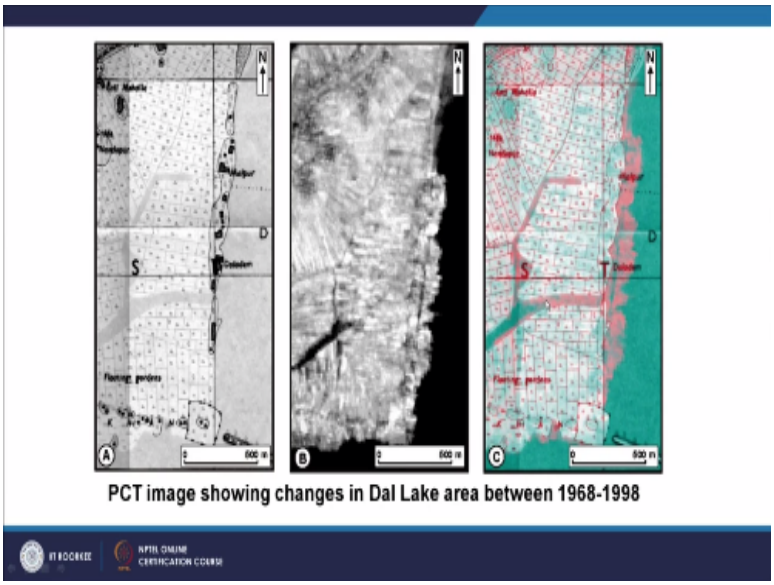

We use as and we split it one and we used as intensity map and then you are having one more channel and the same channel is repeated here, so instead of having three RGB, now we are having two and one is being repeated and with the output what output is showing very interestingly it is showing the red color these are the whole changes which as occurred between these 30 years the map belongs to 19968, the satellite image belongs to 1998 so there is a 30 years time difference in between the lot of encouragement has occurred on the edges or perimeter of the lake.

Even in the these water ways also we achieved by growth vegetation and that is very much reflected here, but the first requirement is registration so map so we register first with the image then instead of having three channels one can have even two channels one is map another one is satellite image and then both are single note color but splited into three color and three intensity huge and saturation intensity image was taken here band three was taken here band three was repeated and then you get this.

Kind of output so it doing like this we can create a new product which is telling how things have change so the color is space can also be exploited is being exploited is a exploited extensively in change deduction study whether these change is or manmade of natural whatever is because since 1972, now we are having data, satellite data so we want to see the changes what has have been last 43 years of lake or 45 years and we get the old image no matter how that what was the

special resolution of land side matters and what is the special resolution of say and land said well IICS that is land satellite 8 images.

There is a change now a special resolution but we still to special two different special resolution images with exploiting color space color cube can be merged together and it change it action image which will tell you very distinctly whole things have change another example another part of this June part is shown here that the lake.

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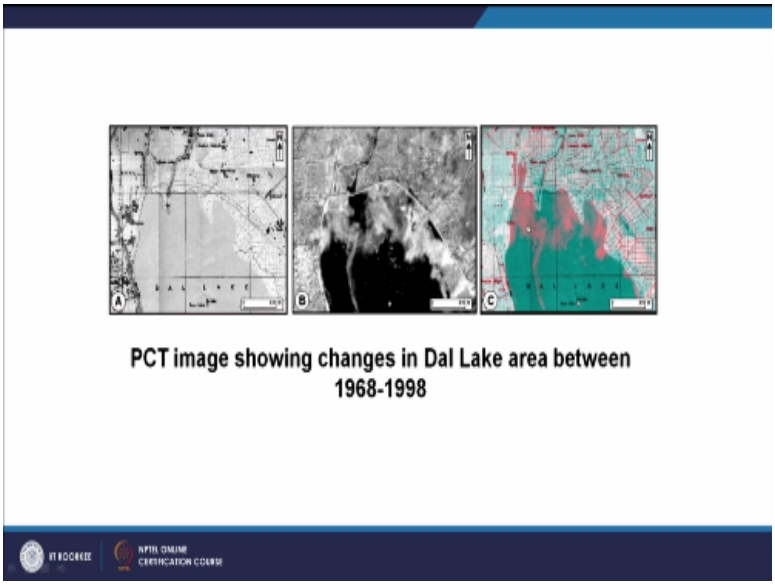

That the lake this is the image and this red all are showing here the vegetation has grown in last 30 years, so this is how one we can explained a color space in change detection has studies as well and one more two more examples from earthquake studies I will show you very simple and here now the sensor is same.

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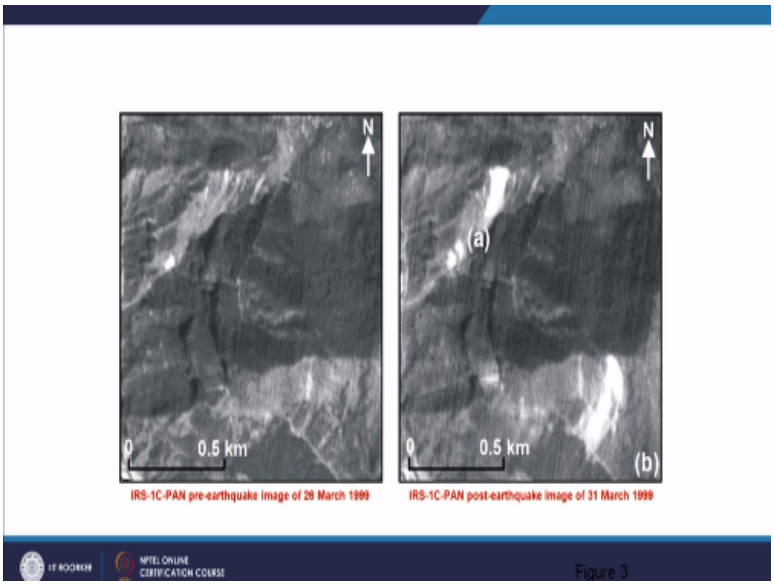

Figure 3

But two different it is and both images belong to the higher span so 5.8m data and this is just 5 days time difference and in between earthquake has occurred, so like this is example from chamilia earthquake, so chamilia earthquake occurred on 29th March 1999, the change what do you see here after five days the another image was occurred. So the same day we can exploit we can because in order to create a composite we need three colors, so one this image was repeated twice this one given the red color.

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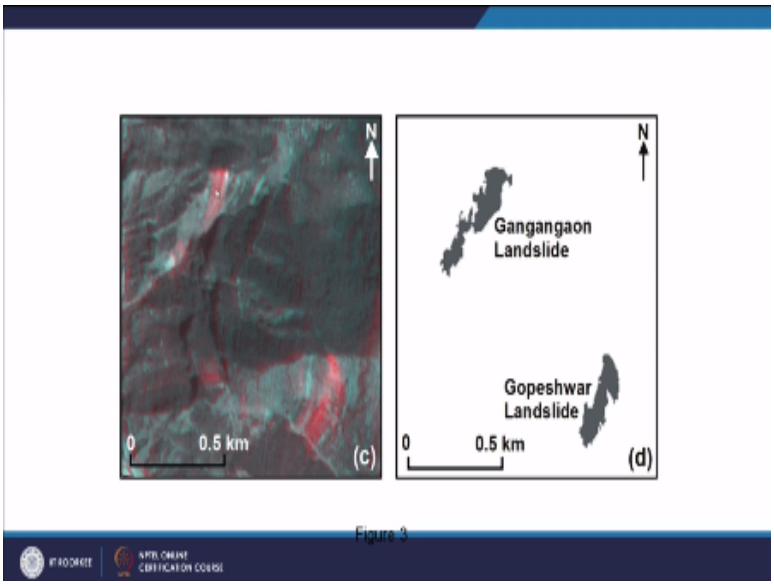

Figure 3

And the output you see here is that whatever the changes which has occurred in terms of reflection induced by an earthquake that is in this case Chamilia earthquake can be seen through red color, and if it is some white spots are there that means you are saying that change has occurred as you can see very well, that they have already some science of philosopher failure and then in between the earthquake has occurred after the day and image was a quite.

And when you create a this pseudo color transform image not it truly falls color composite or a map merged image kind of thing this is pseudo color a new name was given bios that is a pseudo color image can be created which will tell you where changes have occurred between these two dates, and in this case the dates are very closed in case of like dull lake study that dates, time difference was of 30 years here only of five days.

What I am trying to say that the color space can be exploited to maximum for different type of studies, it depends on for what you are going to exploit and use them and create a new product. Another example from the same earthquake same sensor this is pre, this is post when you create a pseudo color transform image you end up with like, so large part here is also in white that means they were already some landslide.

Due to this earthquake, earthquake as a news for the landslide new landslide have come and so this was not there thought there were science of earlier failure but slow failure now it has enlarged, so these landslides have enlarge and the new one has come that is what it, so this shows very nice application of color space exploiting the or creating a new product which is telling

about the changes which has occurred in just between five days similarly, in another example of instead of very high resolution.

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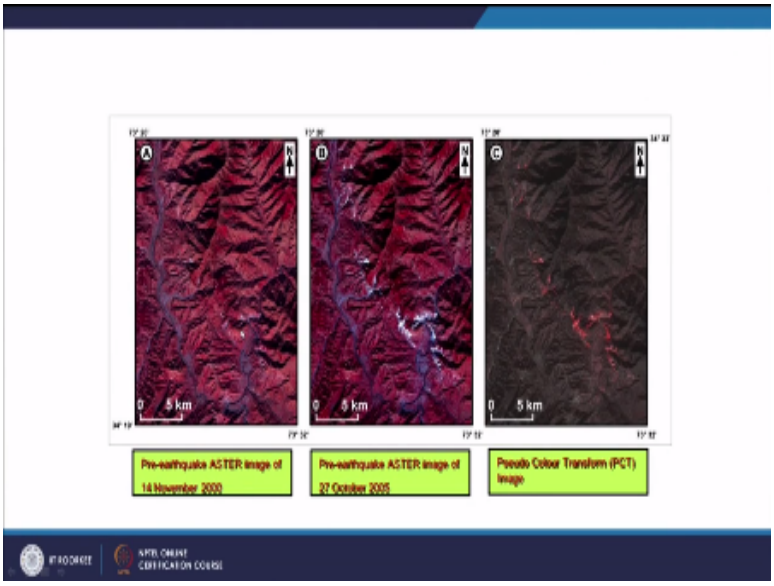

If you go for relatively low resolution and satellite data which is covering a very large area and again the time differences of five years instead if you know 30 years or five days here time differences is roughly five years and you can create change detection map, not only that the orientation of landslide can tell you some other story why they are lined, because of some for and retronick feature which is geological fault or thrust.

Similarly in case of both earthquake where we had a very high resolution data again for individual houses one can exploit color space, color transformation techniques and can create products which will very quickly will tell where changes have occurred, so color space or color transformation techniques are very, very useful for change detection studies

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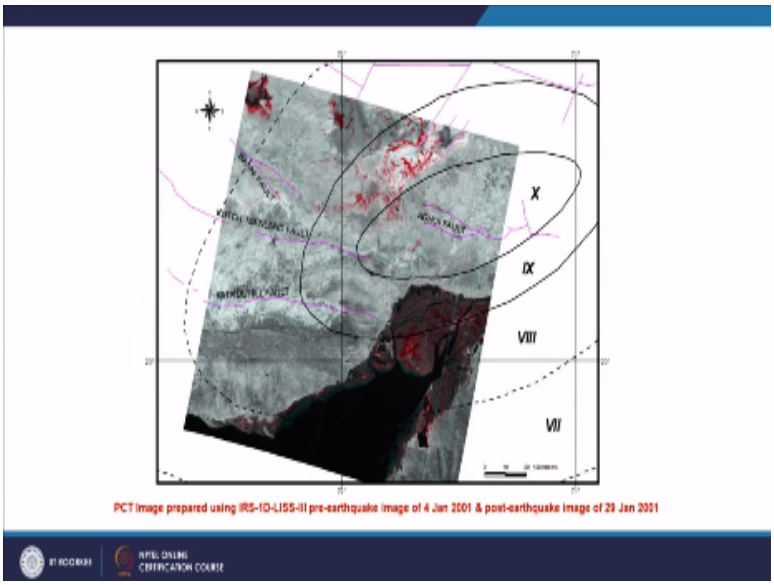

One more example and the last example in this color transformation is that here instead of like pen we had this is the list 3 data and list 3 itself is a multi spectral data, but we wanted to see only the changes in the water and in moisture and the best channel is infrared channel so we exploit infrared channel the same way as in case of, in the pen in case of Chamilia earthquake. But here instead of landslide our focus was on liquefaction which is another coseismic phenomena which occurs during an earthquake event.

And so for pre earthquake image which was of 4th January, 2001 might be remembering the Bhuj earthquake which occurred on 26th January, 2001 so roughly 22 days before the earthquake there were one recording by the IRS-1D less three image was there then after the earthquake on 29th January another image was acquired of the same area luckily both images that means the 4th January image and 29th January 2001 images both were completely cloud free.

So the best thing is just first two do as good as image to image registration as possible which is not very difficult to perform and once that is done then the color space plays very important so what we assign two channels for pre-earthquake and one channel to post-earthquake that is the red channel to the poster and when we do it like this you get this kind of product which you can see here that the water bodies which appeared which is a course liquefaction as coseismic during an earthquake.

And they remain on the surface for some time and where unwisely recorded by the satellite. So all these red area are showing the changes which has occurred between these two dates one and

changes especially related with water either moisture has increased or fresh water bodies appears so there were some drains even developed for some time.

Because of liquefaction the ground water came on the surface and flown for some distance on the surface in that particular area which was mostly large part was affected and due to liquefaction. So it depending on the application one can really exploit such things, another example all together different way of exploiting is this is a list 3 image of Bhagirathi river valley of Himalaya, Bhagirathi is a tributary of gangoueus and this is list 3 images.

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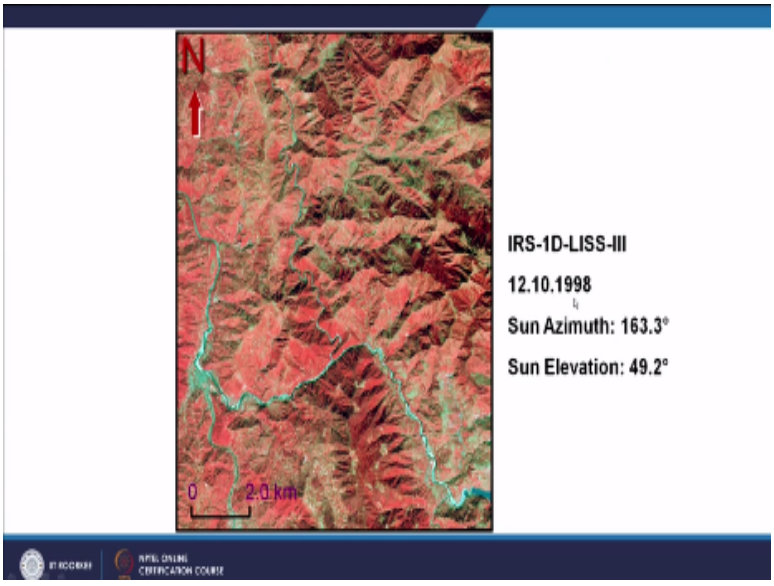

And remember these azimuth and sun elevation angle of 1998.

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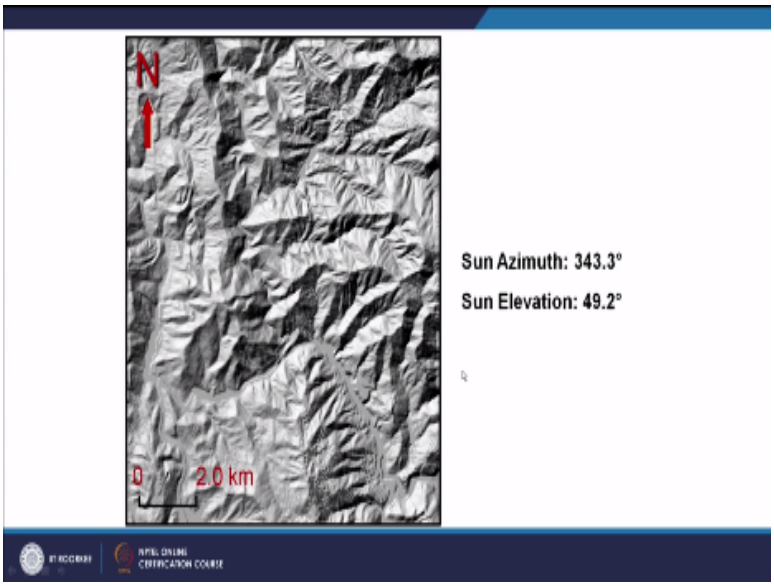

Now this is schedule relief model derived from a digital elevation model which we have discuss extensively in introduction to GIS course and here just recall azimuth angle, the azimuth angle in this case is 163.3̊ it is just adding 180̊ and the sun azimuth is here. Now this image this product which is generated from digital elevation model can we use as a intensity image, and if we split this image which is RGV image if falls curve composite image into three channels intensity and hue saturation hue of less three is dropped and that is replaced by intensity of this one.

And then so intensity image from this one is dropped this is replaced by intensity image this is the schedule relief model and rest hue and saturation continuous and in inverse or backward transformation you end up with this. The purpose here was if you see here you might feel

because of false topographic perception phenomena you might see the river is flowing on the ridge, but actually river should flow in the valley.

But because of certain illumination arrangements and the geometry of the satellite and solar illumination you feel that river is and this phenomena we call as false topographic perception phenomena. So in order to get radio of that phenomena we, one can exploit and can create a new product in which river is flowing in the valley which is and giving you correct perception at the same time you are having colored image.

Whereas your schedule relief model though looks quite close to your satellite image but does not have the colors like your image, so a new exploitation of color space. There are unlimited possibilities with color space as per requirements of the application one can evolve a new technique by splitting and then reverse transformation dropping some channel, dropping intensity may or some other image and you can create a new product. So this brings to the end of this color space and transformation, thank you very much.

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