Remote Sensing essentials
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Lecture-19
Colour Representations and Transformations

Hello everyone and welcome to new discussion which we are going to have on colour representations and transformations under this remote sensing essential course. Though it is a in our school time we have studied all this, but in digital image processing, the concept of colour hue and or colours is very important. And therefore, I thought that just to you know review this whole thing we will go through very quickly on this aspect.

That is colour characteristics and applications in remote sensing because lot of new products can be generated once we understand the basic things about colours. So, there are 3 characteristics of colour which is first one is hue another one is the brightness or intensity or luminance of the object and third one is the saturation.

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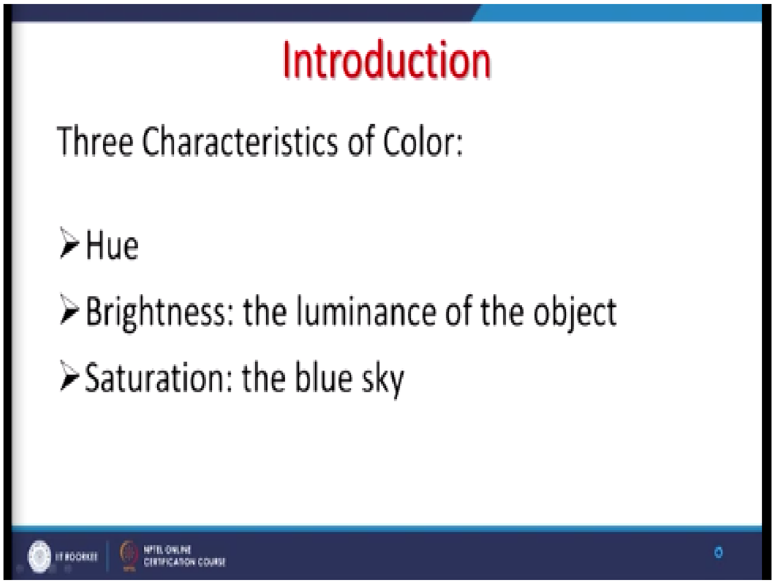

And for example hue also we call for colours, so, different colours try to recall the Newton disk. And in Newton desk in the periferi, all those colours were there 7 colours. And brightness varies from centre of the disk towards the periferi and saturation will also come in between.

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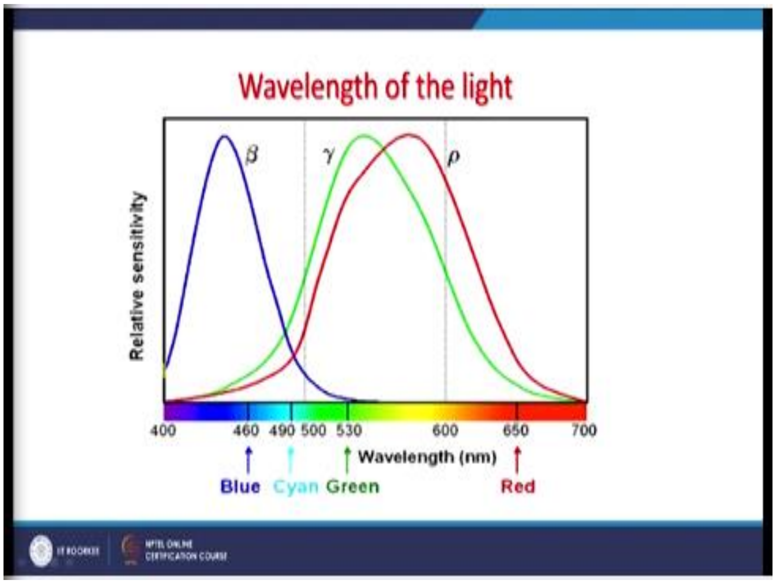

So this is how in the visible part of EM is spectrum when we see all these 3 colours plays very important role. And as you can see that the blue colour comes first and is quite separated with the green and red colour. So, in remote sensing maximum sensors are in the visual part of EM spectrum. And very high resolution sensors, even 40 or 60 centimeter resolution centers are also located in this part of EM spectrum, that is why it is very important.

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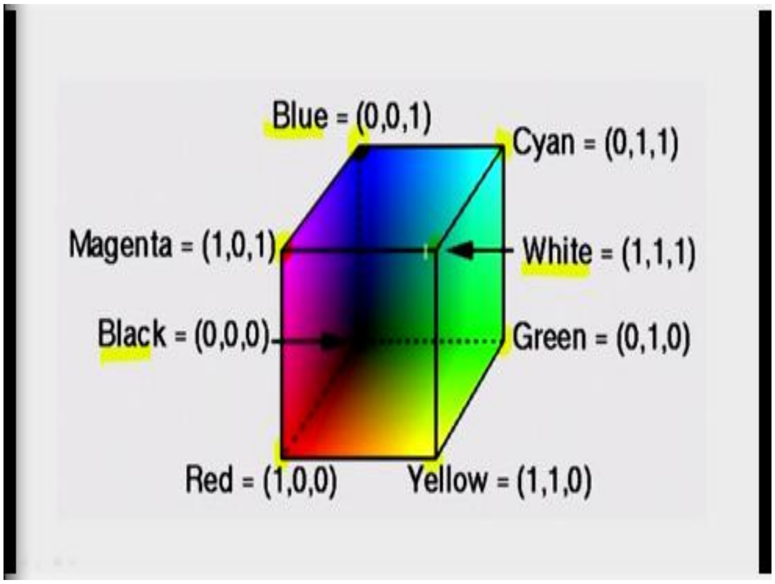

Now, they said colour cube I would like to spend some time on this while discussing this colour cube. If you see in the end that is where the black is marked and that is the extreme corner of the cube which is the darkest. And that one is the black and whereas on this just diagonally opposite corner is the white which is located here.

Now, and there will be you know 6 more colours on the other corner, so total 8 corners are there, so 6 more colours. So if I take then here we are having red, then here we are having blue and then here we are having green. Now 3 more remaining and they are occupied by cyan colour, then a diagonally opposite on the same surface that is magenta colour and then yellow colour. And why this that means, a diagonal access from black to white basically represents the intensity or brightness.

And if you can imagine a cube or rather cone inside this cube then you would find that the you know the base of the cone will have all the use. And you know the apex of the cone or the bottom of the cone will have the black colour on top you would have the white colour. And intensity will vary from centre of the disc in the base away to periphery which I can also demonstrate through this one.

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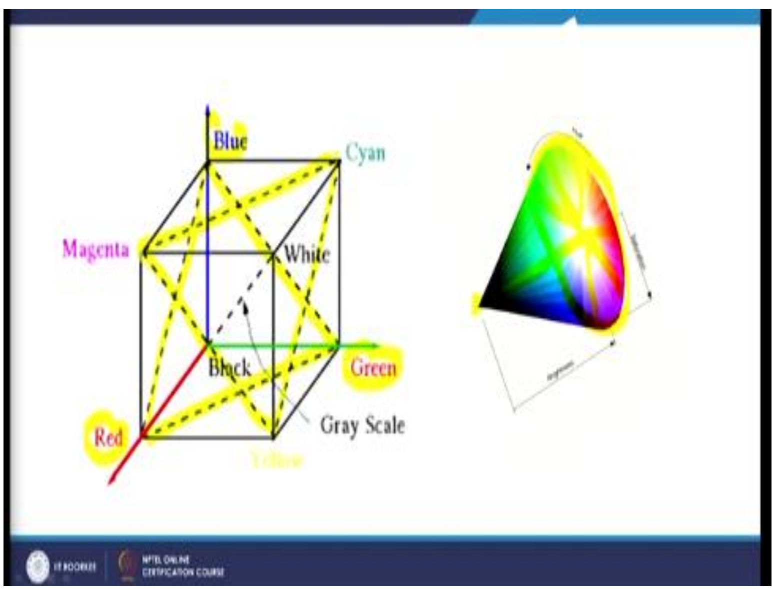

So again the same cube, now colours have been removed only the name of colours have been mentioned in respective colours. And if I take that cone a 3 dimensional cone out of the cube, this is what I was mentioning. That intensity will vary from this bottom or apex of the cone to the centre. So, this is the black and here you are having the white colour you will vary along this periphery like this.

So, that is the hue and saturation is from centre to away from towards the periphery. So, these 3 things 3 characteristics of colours are very important especially when we deal with the colour composites, pseudo coloured composites or emerging images. And then we in digital image processing project in reproject these planes which are fitting in this one.

For example, if I can take a plane that is red, green and blue and as you can see this plane is this one. So, if an image which is using these additive colour scheme that is BGR or red green blue, I can reproject that image into another plane which is cyan, magenta and yellow. And backward and forward transmissions are also possible and this will allow us to create new kind of products through image processing of satellite images.

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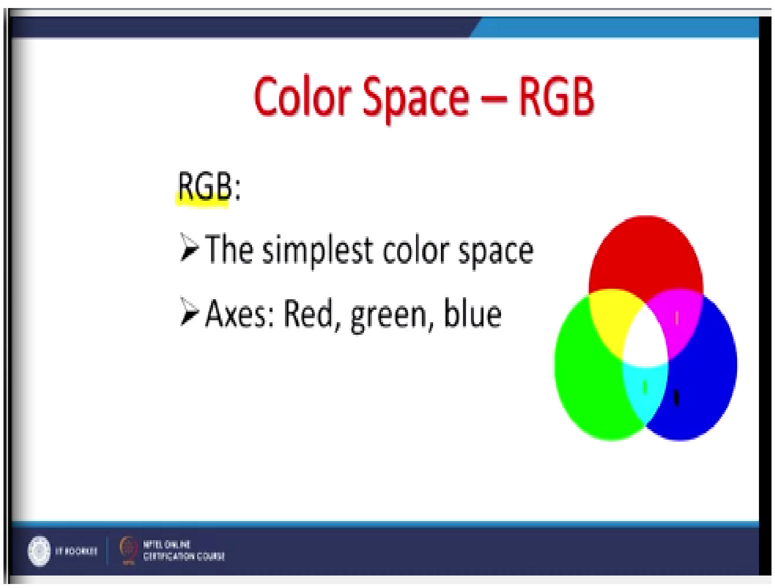

So, we will be of course, discussing this part, now again very basic thing which we have studied in very early a school time. That the you know, this RGB combination which is these 3 disc are there red, green, blue. And then they the like red and green makes a yellow and then this red and blue makes your cyan. And then this makes sorry green and blue makes cyan and red and blue makes magenta.

So, like by, so this is additive colour scheme in standard false colour composites, we use this additive colour schemes. All display devices whether it is a computer monitor, your mobile screen or a projection, every these devices are using additive colour scheme. Whereas all your printing devices they use the other scheme that is subtractive colour scheme which is cyan, magenta and yellow that is subtractive.

So, that we will and as I have already told you that from one plane that is RGB plane, I can reproject it within that calorie space to CM by CM by K also, that is k for black. And so, likewise I can create new products which is otherwise not possible and these new products are very, very useful in digital image processing.

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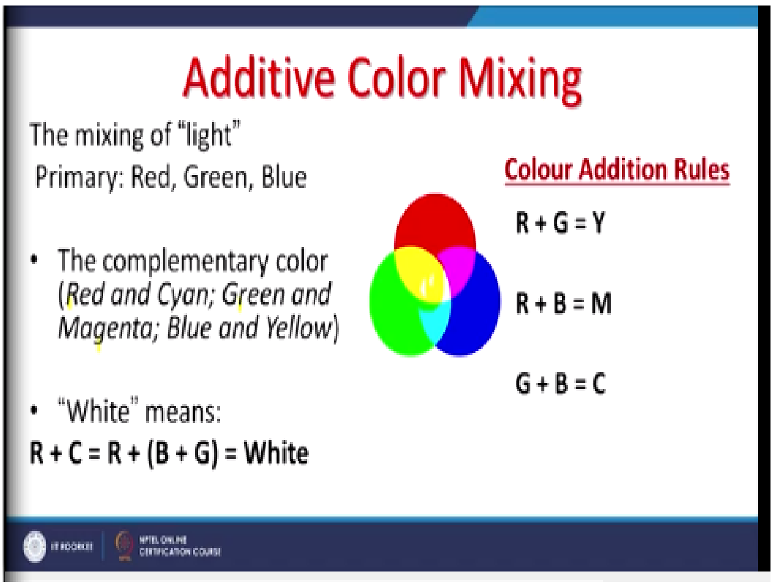

So, additive colour mixing or additive colour scheme which is followed that it is end these are you know like complementary colours red and cyan, green and magenta and blue and yellow that you can also see in the right side figure. And white means that all these red cyan red + cyan = red + blue + green that makes white, that you can also see inside this one.

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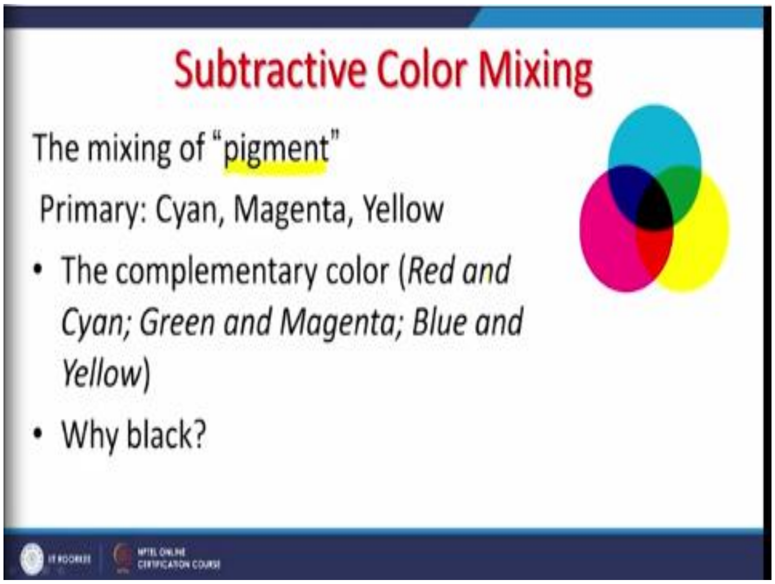

So colour additions, there are certain rules and which this 3 colour disc explains quite easily. And very quickly I will also go to this subtractive colour scheme which is used by the printing and that is why pigment is there. If you see a newspaper which we get every day, if you see in the bottom of that page, you would find 4 dots cyan, magenta, yellow and black.

These dots are used basically for calibrations to know whether all flow of these pigments are coming into the printing of these newspapers or not. So, that clearly shows that while printing they use this subtractive colour scheme. Again these are also primary colours cyan, magenta, yellow, complementary colours can be red and cyan, green and magenta and blue and yellow. And when we say black then all these colours are there then it makes black.

In printing devices, because why to waste colours, so, there is a separate cartridge. So, whenever you open a colour printer whether it is an inkjet or laser jet, you would find there are 4 cartridges, one curve. One is for cyan, another one is for magenta, then yellow and then one more is for black. So, whenever you ask printer to print a black and white print, then it would not use the colours it will use just black cartridge and print in the white background just in order to save these things, so C M by k scheme is used by printing devices.

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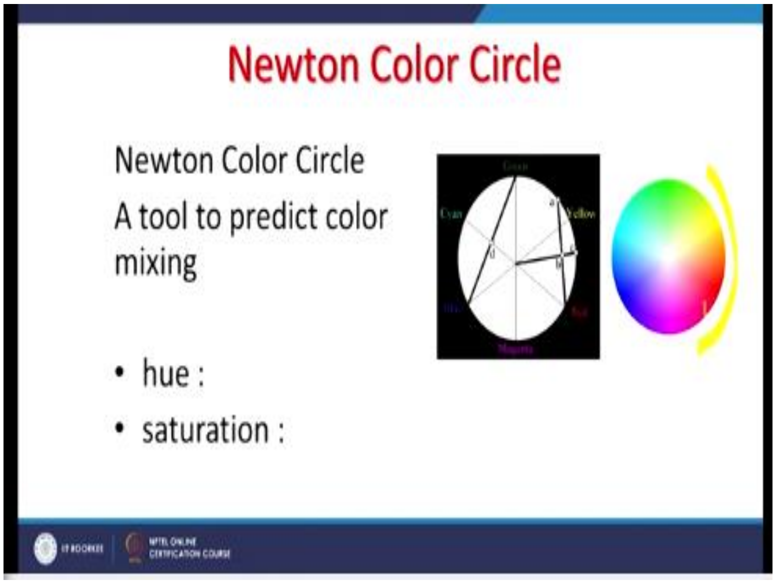

Now this is the Newton disc or Newton colour circle and this one in our school time, it was put on a as a wheel and when we use to rotate, we use to get a completely white colour through coming from this disk. But the condition is that colour should vary like this which is shown here. If they are completely marked separately and even at whatever speed you rotate, you will not be able to see white colour. So, this is very important here, again these 3 components will play role hue, saturation and colour.

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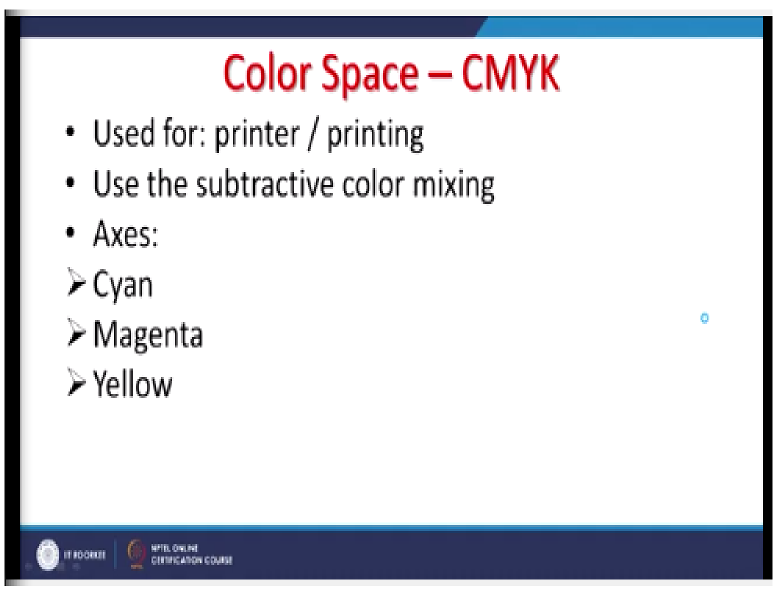

Our this intensity brightness, printing devices I have already mentioned and which follow the subtractive colour schemes. There are 3 axes are there cyan, magenta and yellow, recall the a plane within that colour cube on which things are being projected. So, what you see on your screen, generally that does not come through the printing devices. Because there is a transformation from RGB domain RGB plane to CMYK plane.

So, that is why what you see is not what you get, it depends on your screen settings also. So, one has to be careful about as to what to expect from a printing device. If any of these colours are sort in your printing device again you will not get what you expect. So, this CMYK scheme is used by printing devices. Now, it is possible as you know transformation either from RGB to CMYK or reverse is also possible.

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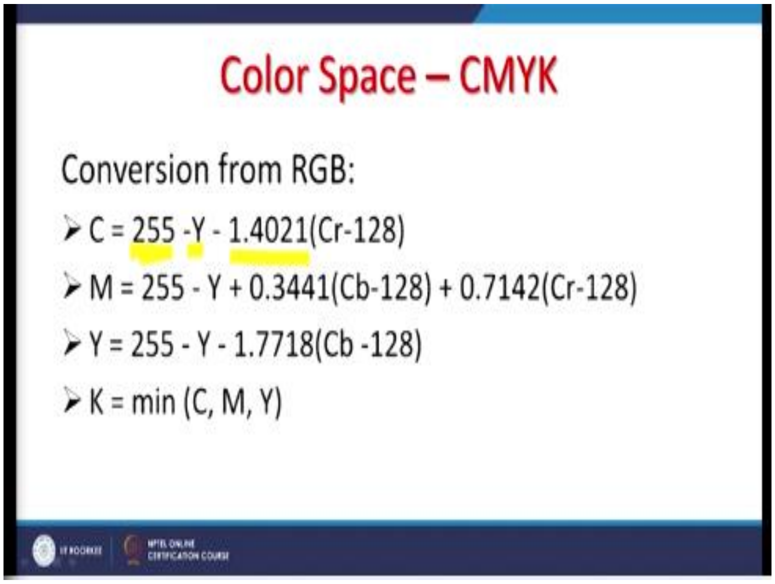

So, if I want to have cyan then 255 minus in case of 8 bits scenario we are talking. In most of our digital image processing discussions, we will be having these scenario, 8 bits scenario. That means values are varying between 0 to 255 total 256 labels. So, by minus yellow and then you use this a constant and then you get these colour cyan, magenta, yellow. As you can see that these transformations are also not fully you know transparent.

And therefore sometimes what you see on your screen you do not get through the printout, so that one has to be aware about this part.

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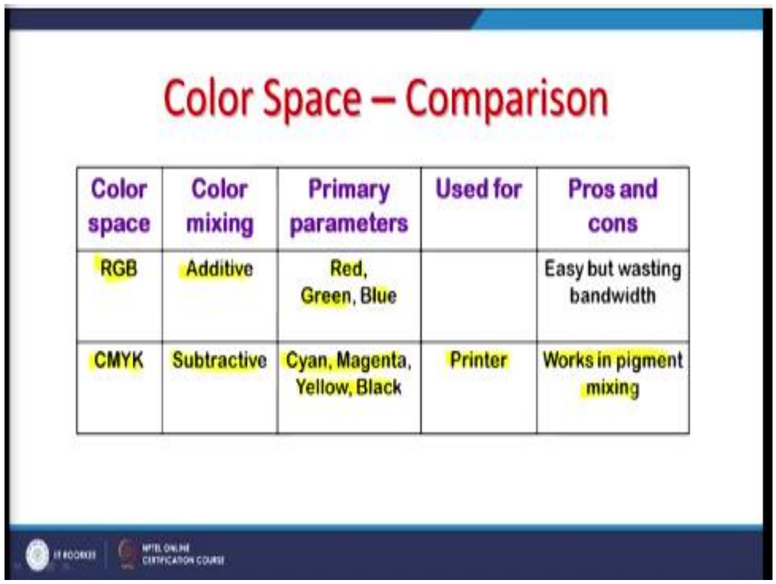

Now, there are advantages and disadvantages and in overall somebody when we use the RGB out in within that colour cube which is a additive colour scheme. The primary parameters are red, green and blue colours are there and use for display here. And is he but, wasting bandwidth if we go for you know negative point of this. If we go for CMYK which is subtractive colour scheme 4 primary things cyan, magenta, yellow and black.

It is used in the printing devices and works in pigment mixing etc. So subtractive colour scheme is used by printing devices, RGB or additive colour scheme is used for display.

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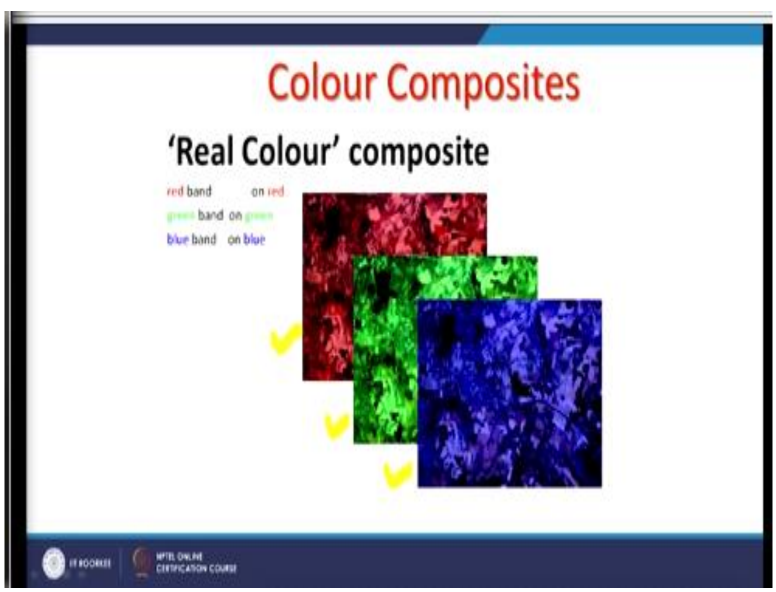

Now, we come to our real connection with digital image processing and by creating a colour composite either false colour composite or real colour composite. And as you know that 3 colours we required to create a colour composite. In this example all 3 RGB are G and B are shown here and then I can make a colour composite something like this.

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Now, this is a real one because here this is not false colour and therefore, I am not seeing vegetation appearing as a green colour. So, if I am having that choice, if a in multispectral data if I am a lot of bands. Then it is possible to create a near real colour, truly it is not real colour, but near real colour composites. And poor interpretation purposes, it is always good to use a false colour composite.

Because vegetation will come out very clearly, water bodies will come out very clearly and other features also you can distinguish easily and interpretations becomes much easier. So, it is in standard practice that we create a standard false colour composite for image interpretation. Of course classifications and other things can also be performed on near colour composites or false colour composites not a problem.

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Sometime people also use word that true colour, again it is not exactly true colour which is near true colour composites are there. But nonetheless if a lot of bands are available, like in Landsat TM ETM + sensors, then these combinations are possible.

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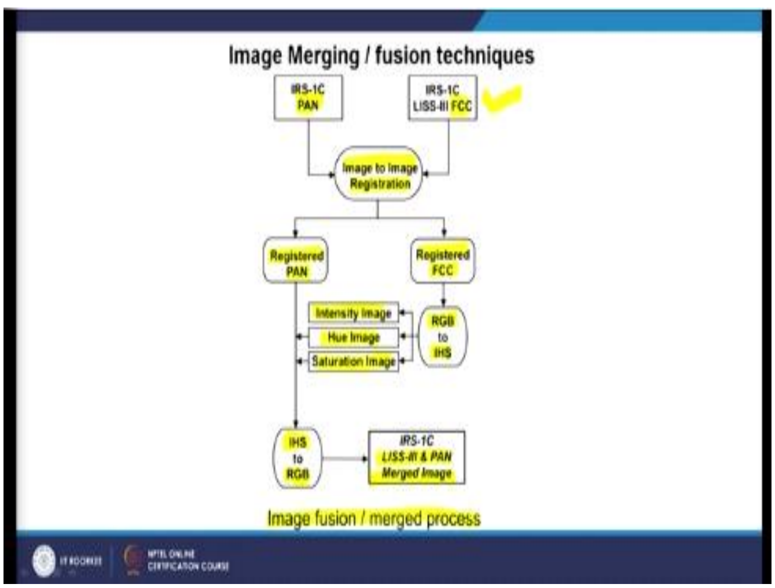

Now, I will be showing some examples of how we can create or exploit this colour space and play with that and can create a new product. So, the example which I am going to have is a 2 images of the same area and they are perfectly registered. So, that they come top of each other having 2 different spatial resolution IRS-1C which is having 5.8 meter resolution.

And LISS 3, IRS once you LISS 3, same satellite but sensors are different and this spatial resolution is 23.5 meter. So, but IRS LISS 3 is multispectral, that is why the FCC is mentioned here and this is PAN, so this is panchromatic. However, the PAN image is having higher spatial resolution but a LISS 3 image is having higher spectral resolution, there are currently in FCC 3 bands on there. So, what the aim is to bring colours at 5.8 meter resolution by doing this image merging or fusion technique.

And by this we can create a product at 5.8 meter resolution and that too in colour and that I will be also showing. So, these are the steps, simple step one has to follow, the you 2 input images they have to be co-registered, so they fit with each other. And then you take this registered image and keep as a separate whereas this FCC that registered FCC, it is splited into 3 components from RGB to HIS.

As told in the when we were discussing colour cube, that I can project from RGB **to** to CMYK. And one more plane, I can touch that I adjust that it stands for intensity hue and saturation, that is also possible. So, I can project my RGB plane or RGB image into a new plane which is IHS intensity hue and saturation. So, I will having when I split this RGB image, I will be again having 3 images, one is for intensity another one is for hue, another one is last one is the saturation.

Now, this intensity image which is coming from FCC is dropped here and it is basically replaced by the registered PAN image. So, we reach and the hue image and saturation images are taken as it is, because again I am going to create an RGB or false colour composite. So, now a backward transformation from IHS to RGB is done. And when I do it because these images are already co-registered and therefore, I create a merge image which is having the quality of both the images, PAN and LISS 3.

PAN, I will repeat again is having higher spatial resolution there is whereas LISS 3 is having high spectral resolution. So, I want a product which should have a high spatial resolution as well as high a spectral resolution and by this image fusion or merging process we can achieve this thing.

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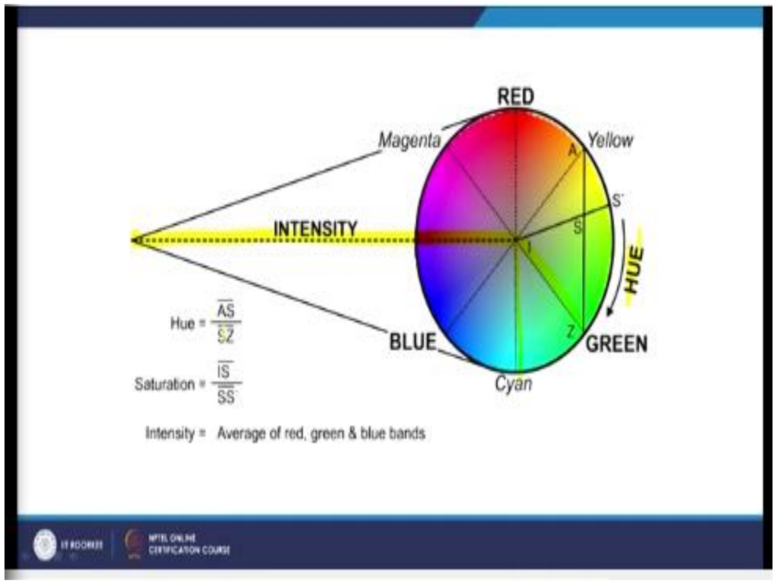

I will show you now some products also this is what I was mentioning about this the disk. And hue saturation I can project intensity I, H is hue and saturation is from here from centre to away how the colours are saturated. So by that this is how through these vectors, I can get all these values and this is how the transformations can be achieved.

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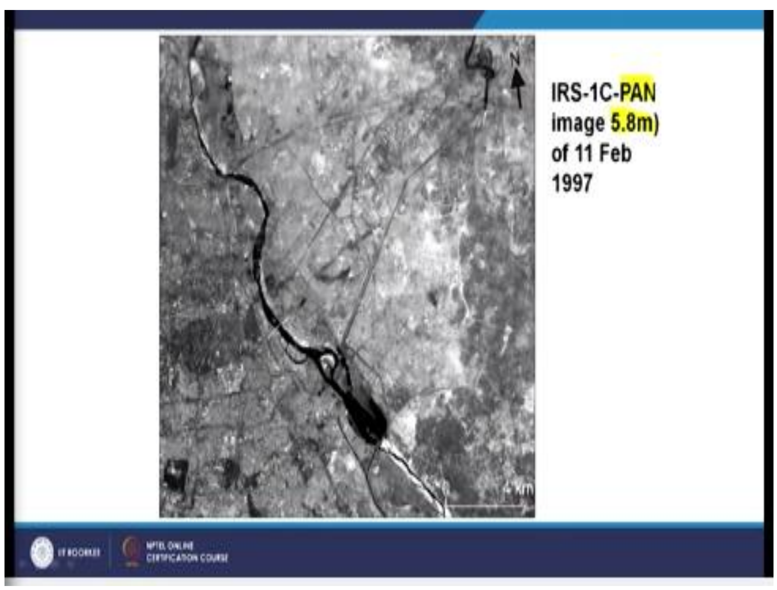

And now this is input image which is having resolution of 5.8 meter, and this is coming from PAN, black and white, of course pen chromatic means black and white here.

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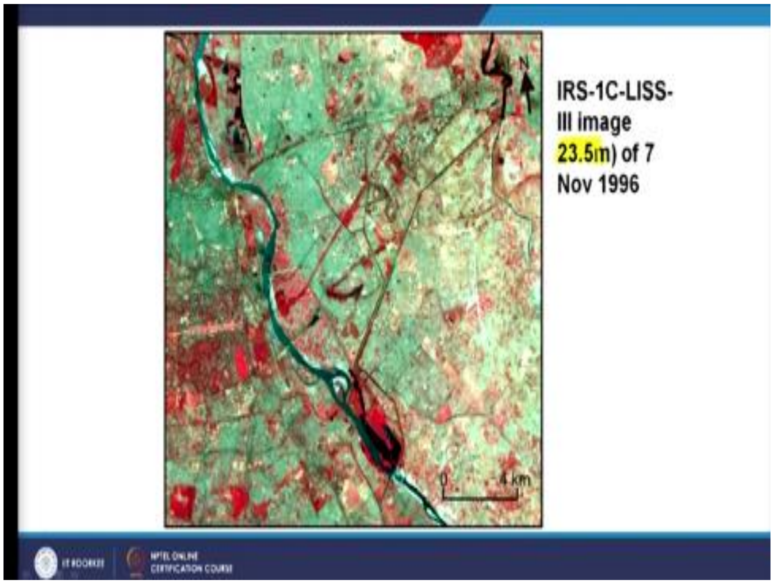

Now, I am having a false colour composite, but it is at 23.5 meter resolution. So, this is colour but at low spatial resolution and this is PAN image but at high spatial resolution. So, now product what you see is having high spatial resolution as well as colours. Colours are not exactly as what we have seen in FCC, but some adjustment can be done in almost same colours can be achieved. Here you may not be able to see that improvement which has taken place in that false colour composite.

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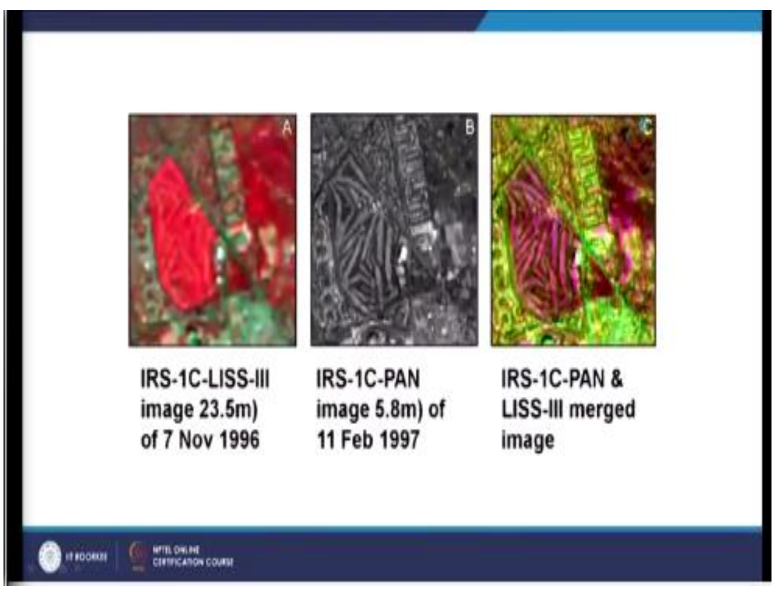

But let me do a part of this one and this is Delhi golf courts, as you can see that a LISS 3 image is not showing that golf courts very clearly, all the holes 18 holes are there a standard golf courts and you do not see all those holes very clearly. But when we go for PAN image at 5.8 meter resolution, I am seeing these holes and tracks very clearly, but it is in black and white, so the right hand side image is the merge image.

Now I am seeing in colours as well as at high spatial resolution. So, just playing within that colour space, colour cube, I can create new products using 2 images of the having different spatial and a spectral resolution. And I can create a merge product which is much more useful then separately these 2 products. And this is what that the concept of colour space is used directly here, to create these products.

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When we develop this one this image what you are seeing here also and along with the article was published as a cover page article by me in the year 99. And since then people have adopted this scheme or this way of creating fused or merge mages and creating a new product which is coming from the concept of colour space.

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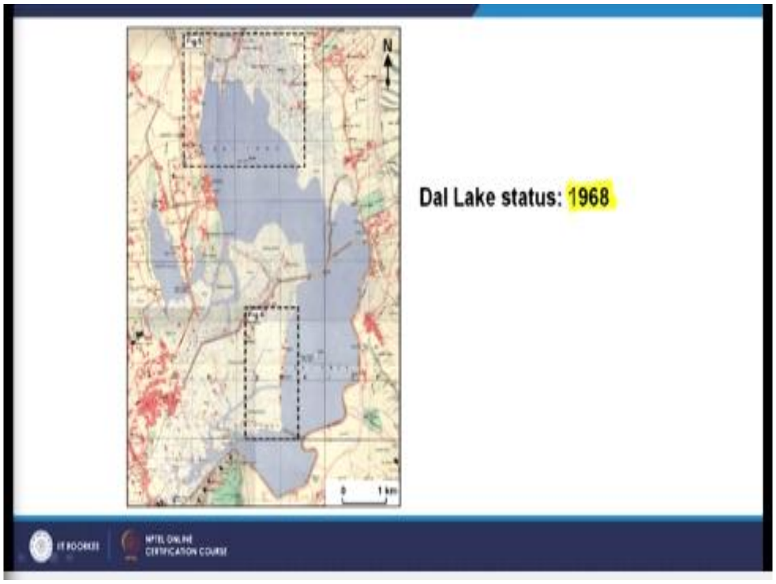

I will give you one more example, instead of merging 2 images, one can also merge map an image and for certain project this is what it was done. So, what you are seeing here is at largest scale a map scanned map, that is also in colour. And this is 1968 because we wanted to study chain detection, which has taken place in terms of vegetation or encroachment is Dal lake of Srinagar, Kashmir. And so we got a reliable map of course from survey of India of 1968.

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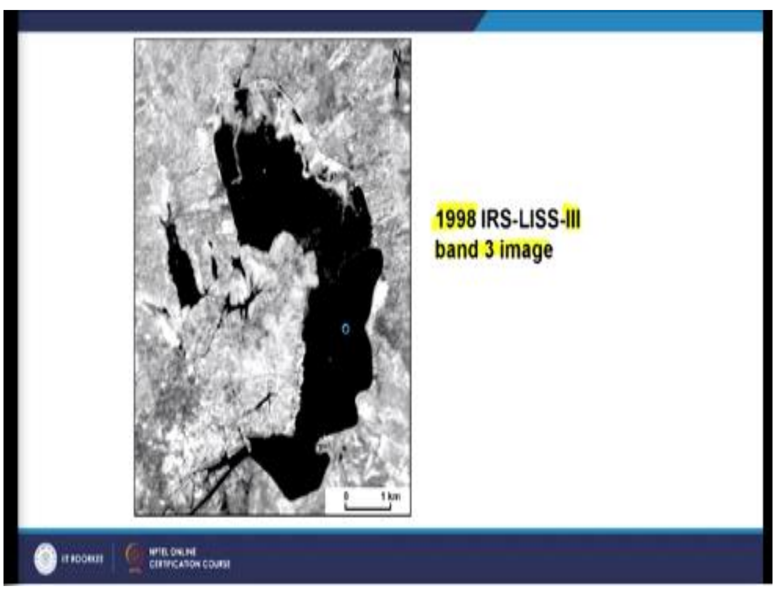

And then we had a satellite image, so this is 30 years time difference, 1998 that was 1968. So, this is LISS 3 image and this is band 3, because this is infrared channel and the advantage here that I wanted to have water body very clearly. So, because in infrared water that infrared radiation is completely absorbed by water and therefore we get black signature of water bodies.

So, water bodies can be distinguish in the infrared channel. Now, using this, these 2 inputs one is this map which is in colour this image.

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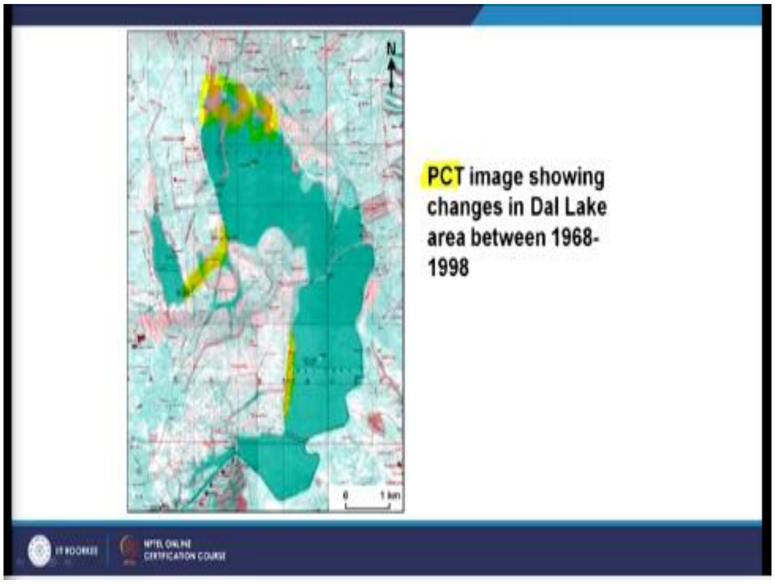

I could create a product, new product and which we call as pseudo colour transform image not a false colour, not a merge but it is a pseudo colour, why pseudo colour. Because you know this image of 1998 was assigned red colour and 2 components of this coloured map we are assigned green and blue colour. So, when you go back to from IHS to an RGB transformation, then you get this kind of product.

Now, this became very useful for a particular project that we wanted to show that where encroachment has taken place. So, like in this part and near Dal gate or in the northern part of the lake. Because of farming or you know pollution in the river in vegetation and so on. Further we also notice that in 30 years time, the channel which use to connect and Nigeen and Dal lake was also encroached or blocked.

So, though no navigation of Circar as was possible in 1998 or later on. So, if somebody would like to restore the shape and size of 1968 status of Dal lake, then these are the areas where this encroachment has taken place. And these are the areas which should be clean, so that we can achieve the 1968's status has blowup part are there.

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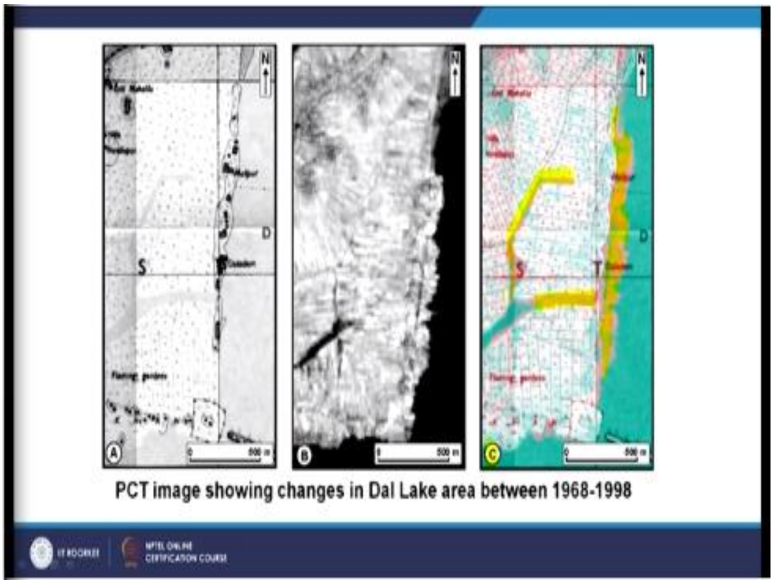

This is the map and just one component out of the colour, this is a satellite image in the middle. And the sea is on the right hand side is the output end, as you can see that this red part here what you are seeing which I will make it is mark here as yellow. And this is the part which has been encroached in 30 years, plus this channel has also been blocked. There are a few more channels which have been blocked. So, red colour is showing the changes which has taken place in terms of vegetation within that water body.

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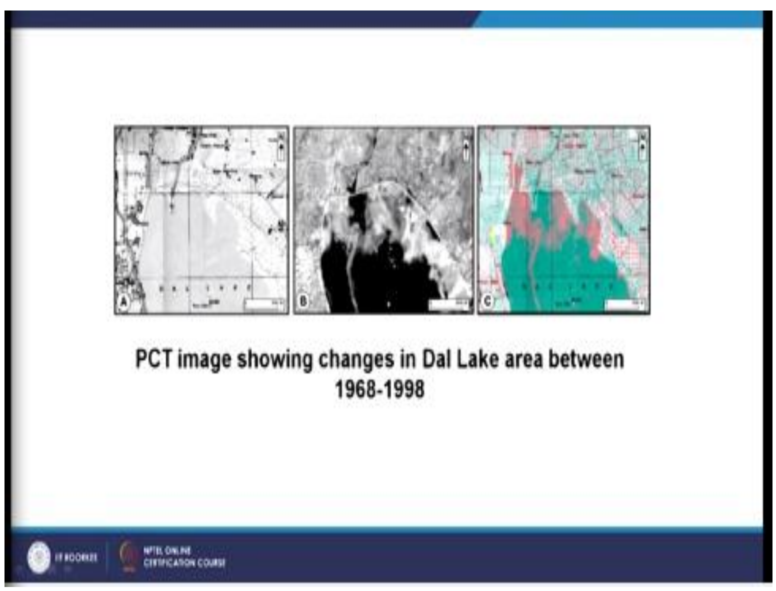

One more is the northern part, again you can see that here also you can visualize that the vegetation has come here. That is why it is giving high reflectance in infrared channel and when you create a merge map, image merge product altogether a new concept and then you get a clear cut marking of encroachment. And if we want to restore then these are the areas should be cleaned.

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Again this work also came as a cover page article in International journal of remote sensing. The why I am all showing this, the purpose here that how you can really play in your digital image processing softwares or photo editing softwares with these images. Once you understand the whole concept of color space, then this play is possible and you can create new products as per your requirements.

Because many times you know the conventional approaches may not produce those results which are useful. And also you know acceptable to decision makers because decision makers are looking for different purpose. Ultimately why all we are doing is to create you know some platform for better decisions. And for that this concept of colour space is very important. One more example I will be showing, again, this is related with chain detection there are 2 images of an pre-earthquake.

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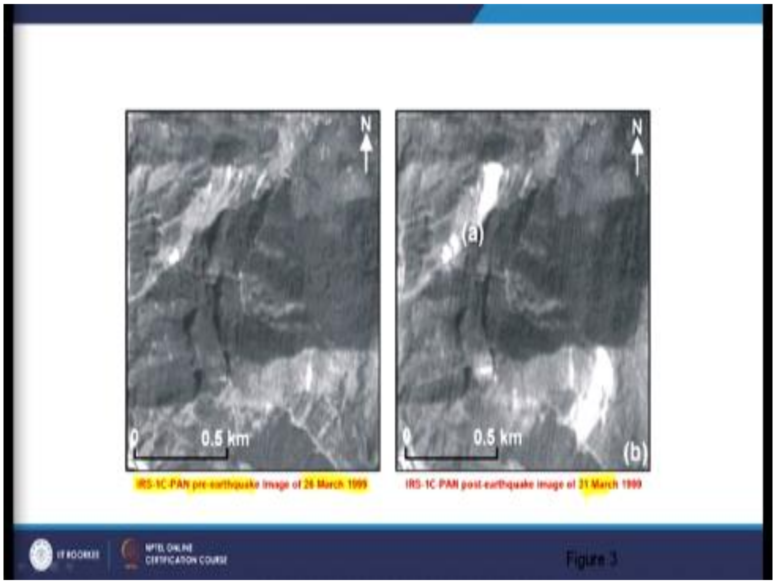

There were earthquake in Chamoli in March 99 on 29th March 99. So luckily we had an image from our IRS-1C satellite panchromatic single channel data. And of 26 march just 3 days before the earthquake. And when satellite was on the adjacent orbit it had the capabilities to steer. That means if one can tilt the camera and the camera was tilted and the same area was again looked by the same satellite same sensor.

And that is on 31st march that is again at 3 days after the or rather 2 days after the earthquake. So there is only 5 days difference between 26 March to 31 March and in between on 29th march earthquake has occurred. Now, we wanted to map exactly where earthquake induce landslides have occurred. And when you again use that pseudo colour transformation technique because for colour image you require 3 image, 3 bands, 3 channels, but here I am having only 2.

So, what we did, we assigned for the post earthquake image, we assigned red colour and for pre earthquake image for blue and green, we assign pre earthquake image. So, this image on the left side that is pre earthquake image was repeated twice for green and blue. Whereas for red channel the post earthquake image was kept and by this you can create an output something like this.

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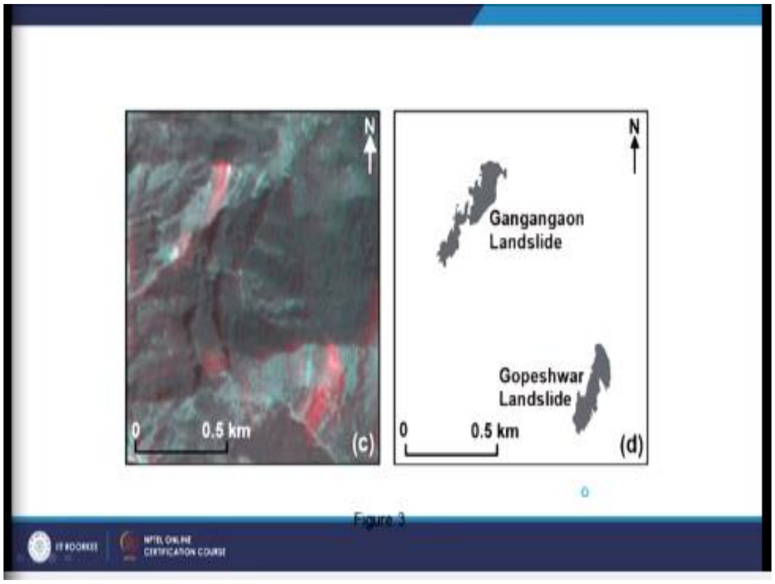

Where all these red colours in the image are showing the changes which has occurred between those 5 days and hopefully they are induced by that earthquake**.** So, we can attribute very confidently that this is because of the earthquake phenomena which has occurred between these 2 dates. And since these are digital images, so you can mask everything except the red colour, bright red colour and this is what it is done.

So, exactly how much area was involved in the landslide that can be seen or that can be mapped very accurately. So, and the areas which are having white colour they are showing no changes that means no changes in terms of reflection. Because when landslide occurs, the whatever the top surface might be having vegetation or grass or that things are all uprooted. And fresh surface, fresh material is exposed and the you know the brightness will increase.

And therefore as you can see in the post that these areas became relatively having high pixel values compared to the pre earthquake image. So, rather than looking 2 images simultaneously and seeing the changes, we can do digital image processing. We can do the colour transformation, pseudo colour transformation create a product which is everything in just one single image.

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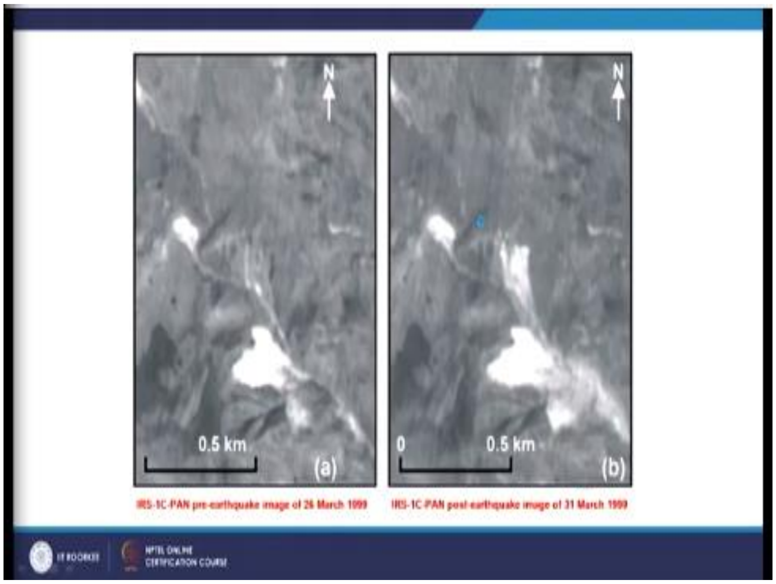

One more example from the same earthquake of the landslide that on the left side, you are having pre earthquake, on the right side again you are having post earthquake image.

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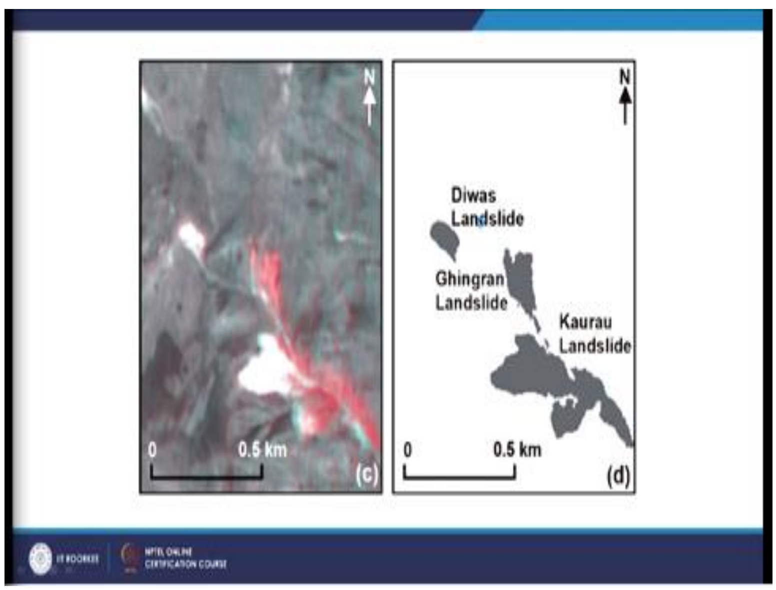

And when we created a PCT. This is how you get, so there are white pages which are saying that no change has occurred between those 5 days. That means these landslides were already existing white part, whereas the red part is telling that this is what the changes has occurred between those 5 days. So, in that way, it becomes a very unique product to exactly map landslide affected area or also if you want, you can know which were the existing landslide and which were the induced by the earthquake.

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And likewise again when we found that this is the new technique which we have developed specially for assessing the change induced by an earthquake or landslide induced by the earthquake the submitted to the journal and it is pass accepted as a cover page article again in International journal of remote sensing.

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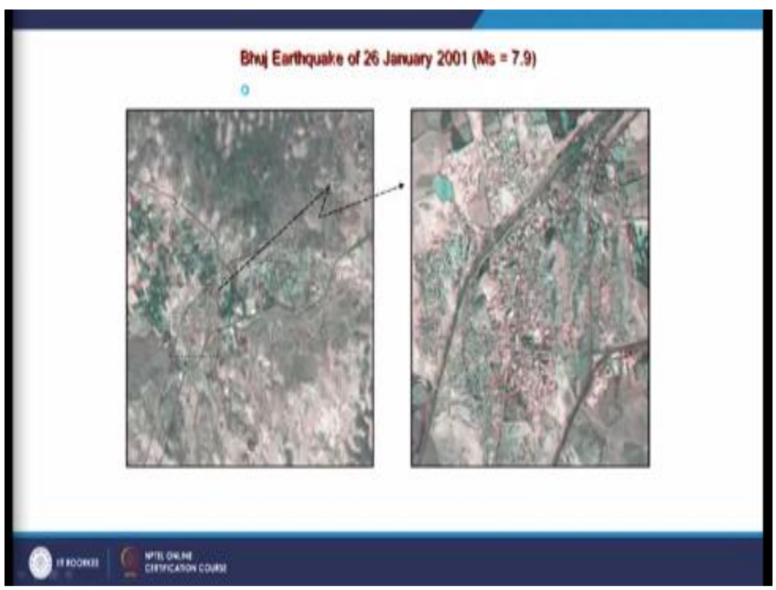

Similarly, the same technique was also used later on in other earthquakes also.

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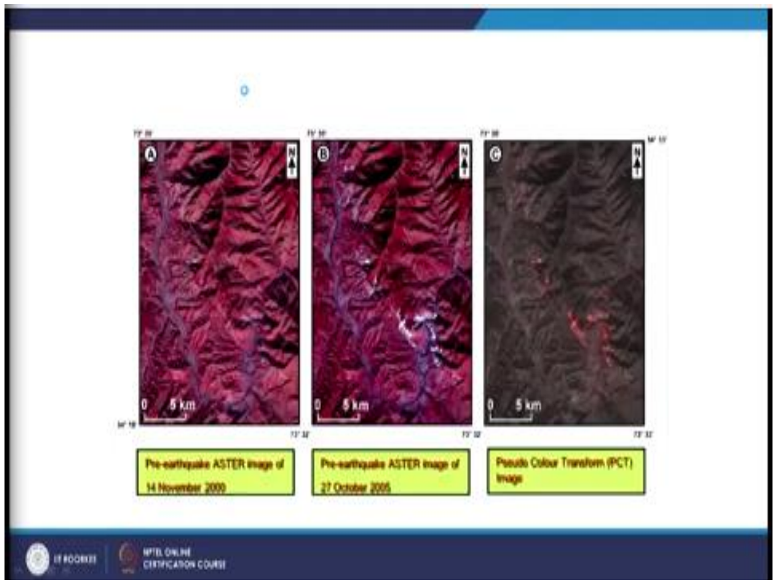

And that was in POK earthquake Pakistan occupied Kashmir earthquake. And as you can see in the centre image is the left image is the pre earthquake image the centre images the post earthquake image and the right image is the pseudo colour transform. Again the red patches are showing the changes in terms of reflection and that means they are showing the changes of new landslides.

Not only these images are telling the new landslide but the pattern they are following in a line and that line geologist will infer as a fault. This is example from Burj earthquake at a very high resolution images of this. And even the changes which has occurred at house level can also be detected using such technique.

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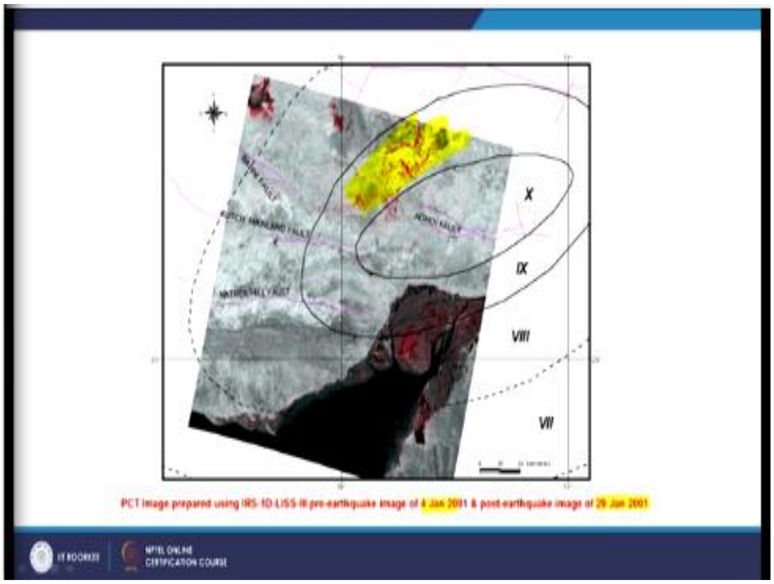

One more example from Burj earthquake and again this was the first time the satellite remote sensing was involved to map liquefaction which is a core seismic phenomena. The main purpose here to show to that how that pseudo colour or concept of color space can be utilize to map various changes which might be induce by an earthquake or flooding or any natural disaster or even manmade.

Here the liquefaction what you are seeing here the new water bodies because of liquefaction they came. And we had the images of 4th January and 29 January and in between on 26 January 2001 the Burj earthquake occurred. And what we see in this part, this part which I am highlighting here ahead the maximum liquefaction occurred. That means water oozed out on the surface which was in the saturated sandy soil due to the shaken it came on the surface, by that time the satellite was also passing and it recorded.

So, we involve pre earthquake image and just post earthquake 3 days after the earthquake image. And we could map this liquefaction affected part very accurately and that was done first time in the world.

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And therefore, again though it did not come as a cover page article, but nonetheless it came as a full-fledged article in the International Journal of remote sensing.

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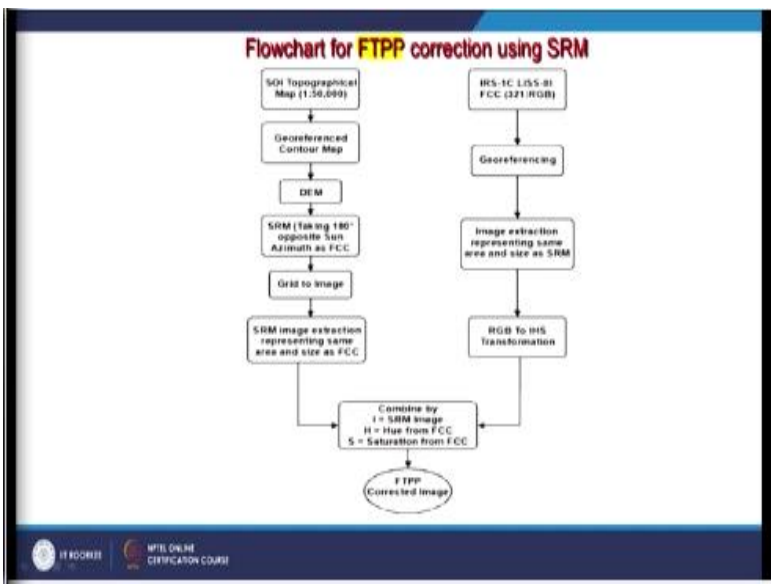

There are other ways also, we can utilize these colour space and one is in false topographic perception phenomena.

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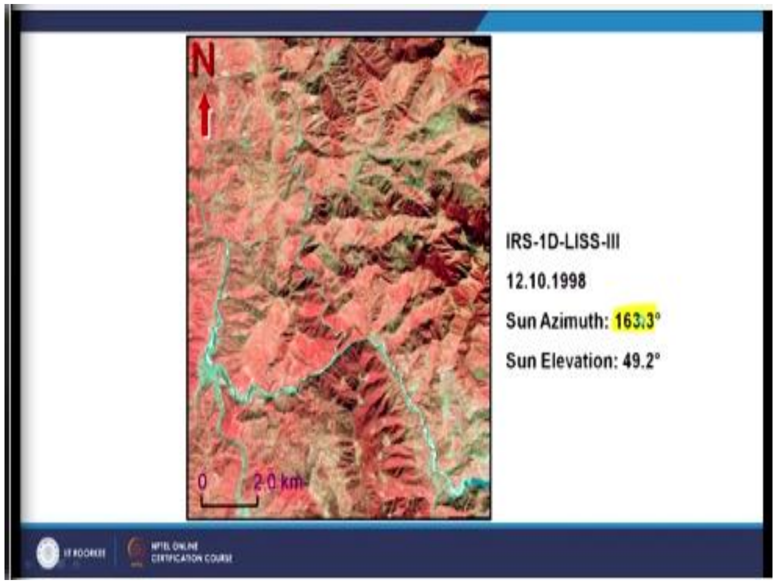

Again, this is the I will quickly go through this one, this is a false colour composite of Uttarkashi area and the river which you are seeing is Bhagirathi river and we wanted to remove this false topographic perception phenomena.

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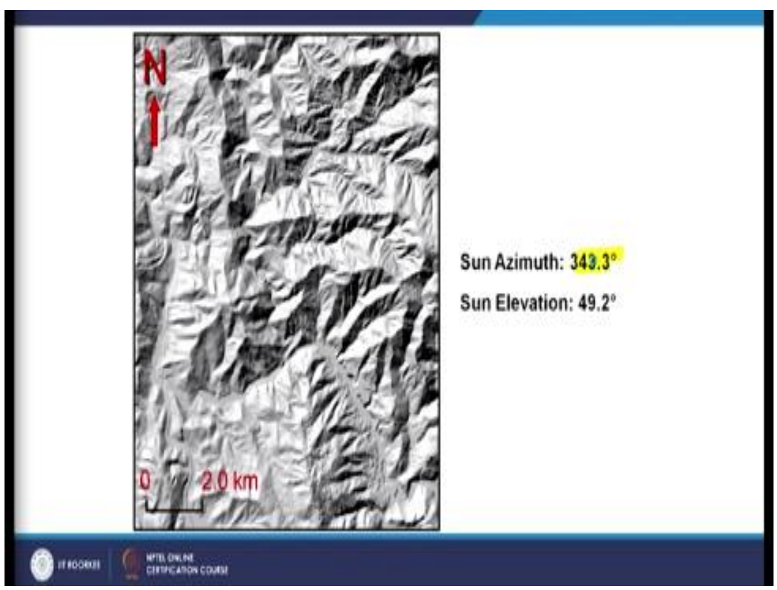

So, this is our input image, this is our input shaded relief model but having opposite Sun Azimuth. Here if you see the Sun Azimuth is 163 if you add 180 degree and then it becomes 343. So, in the image the sun was in the southeast quadrant, but in a modeled digital elevation model based SRM shaded relief model, the sun has gone in the northwest quadrant. So we use this image as intensity image and hue and saturation came from this false colour composite image.

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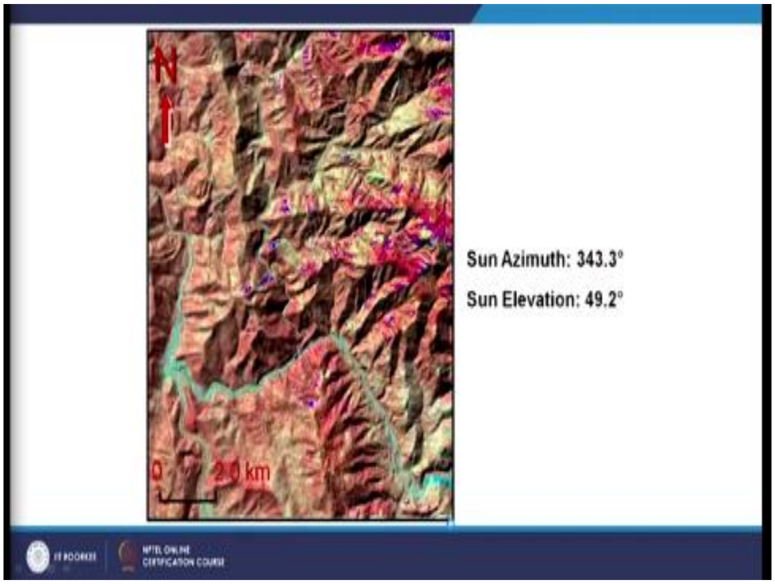

And again the transformation techniques, so when we go for this, this is how you get a product. That intensity is that shaded relief model which is having solar illumination from northwest direction whereas satellite image had the solar illumination from southwest direction 1. And that FCC the satellite image was splited into 3 components HIS, I was replaced by the shaded relief model having opposite solar illumination direction.

Hue and saturation came from false colour composite, and when you go for backward transformation that means from IHS to RGB you end up with this image. In which river is flowing in the valley false topographic perception phenomena has been removed and you see perfect image.

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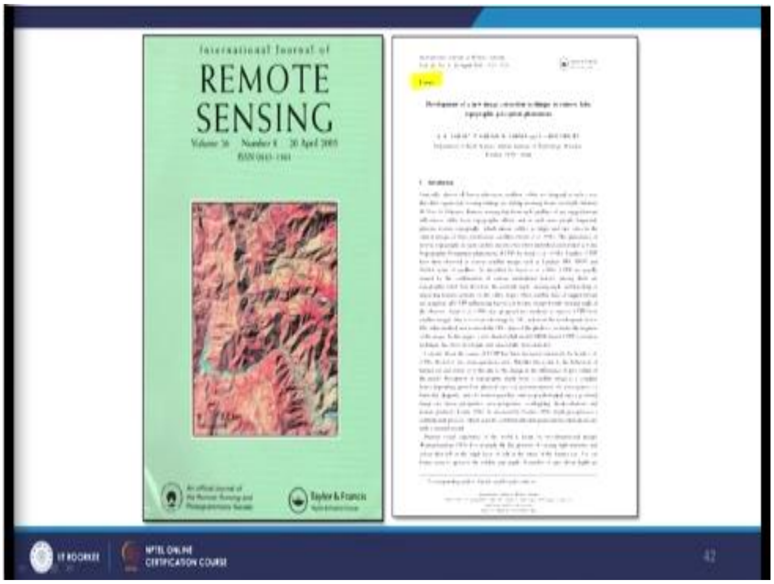

So, there are various ways of creating again, that came as a cover page article in International Journal of remote sensing. So, this brings to end of this discussion, the whole purpose of reviewing the or recalling our concept of color space, additive colour schemes, subtractive colour scheme. That in digital image processing, we can really exploit the different planes within the colour cube and can create very new products especially for chain detection.

Or sometimes to removing some certain phenomena like false topographic perception phenomena. And likewise we can really produce very good results just understanding first about the concept of color space transformations and creating new products using either 2 satellite images of different dates. Like in case of earthquakes, or map with image, a map is very old map generally you get even before landsat that is 1968 map.

So in 1972, onward we started getting satellite images, so sometimes we want to study long term changes which has happened in certain areas. So we have to imply the toposeats or topographical maps, and very old topographical maps might be available to you. So, if you want to use that topographical map along with a satellite image, then again you can do the same way as I have demonstrated here.

There are a lot of innovations within this colour space and transformation can also be done, so this brings to end of this discussion thank you very much.