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Digital Image Processing of Remote Sensing Data

Lecture – 14
Baisc Image Compression Techniques and Different Image File Formats

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Hello everyone and welcome to 14th lectures of digital image processing of remote sensing data, it is a completely different topic so where we have not touched anything about this, but this is very much required in remote sensing and digital image processing, because when you start working for a real project the database becomes very using, because these image is with high special resolution occupy lot of space on your harddisk.

And therefore, we have to find some base, so that we can manage our harddisk space. And also we can perform digital image processing efficiently. And for that there are techniques which are called the image compression techniques the very common one which is not truly image processing technique, but is a data compression techniques which most of us are familiar like [01:17] which compresses or try to compress everyhtng for you.

But how these compression techniques works, which are the types of compression techniques, fundamental compression technqiues are available, which are the compression techqniues, which are though have a level to some extent, but they are copyright protected and so on so forth. So we will see many of these compression techniques the basic one and then different image formats, some of them itself are compression formats.

So we will see one by one all these. So let us start with this that as we know that the image is a two dimensional matrix, it is stored in terms of rows and columns, and you are having the cell value here is the digital number, so is being called as a pixel. So you would be, we also know that the unit, that is the pixel is always is square in shape.

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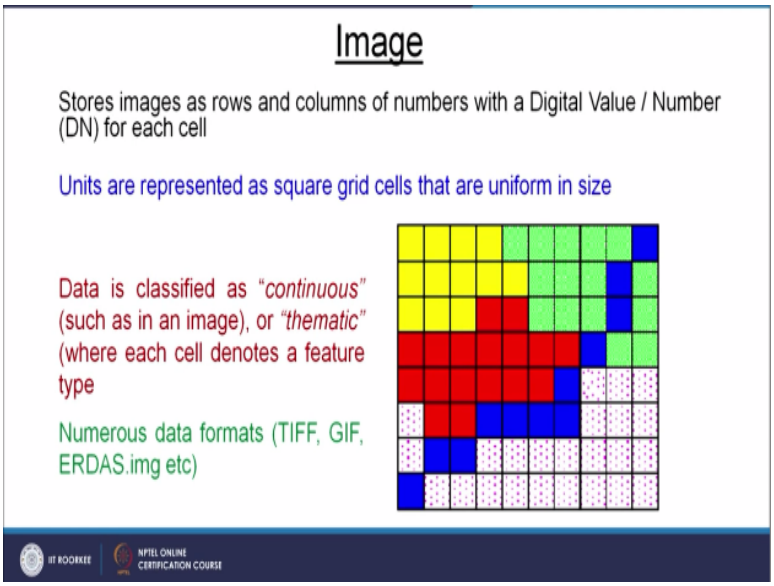

So data is in digital image processing can be classified with continuous our images are continuous or sometimes you have to handle the thematic which may be in that sense, we are also continuous. But in between we do not have many details, but here in case of image for every pixel you are having detail.

And there are various data formats, image data formats which we know, we handle in digital image processing or you will be our digital cameras or mobile cameras like GIF format, JPG format, data is a well known image processing system, so data is having its own format which is called IMG format. So there are nowadays various 100s of image format exist, every format is having some advantages and there are always some demerits associated with each format. So few which are common in our digital image processing palins we will use that one or discuss on them very much.

Before I go for indivudual or four basic data compression techniques I would like to take an example which is very simple one, and we start to understand the data compression and it will be true of data compression, we will start with the very simple example, and are going to take a binary image. Only for our understanding these lines are shown here.

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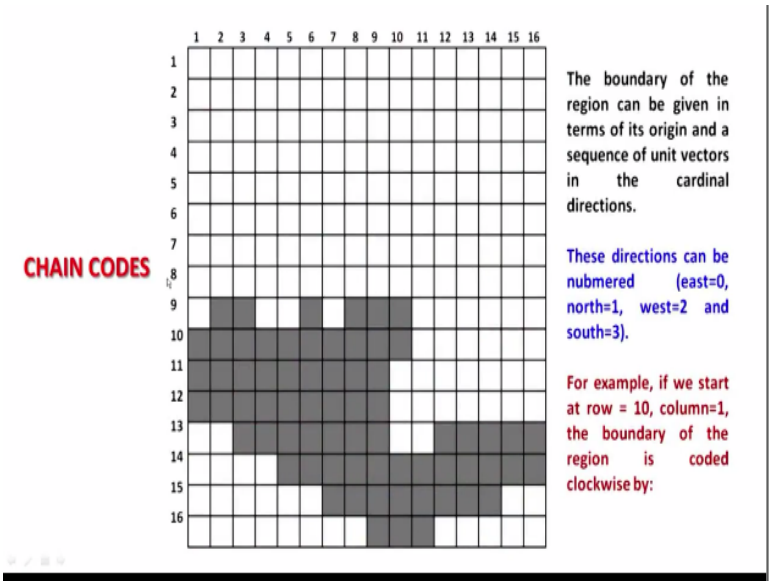

But actually in the true way there are no lines only pixel values or digital numbers are in two dimensional matrix. So this is binary image, that means here we are having a shaded area and the rest is just white area. So there are only zero and one scenario is there, that is why it is a binary image. Data compression for understanding we will look at the binary, but of course on colored image is also or 8-bit images any bit images the data compression can also be performed.

So let us for the first technique which is called chain code technique, and in this one the boundary of the region, so here this is what we will try that the area which is out of white and black which is the area whch is smaller on which the boundary is recorded basically. This is the boundray of this shaded area. So the boundary of the region can be given in terms of its origin and the sequence of unit vectors in the cardinal direction.

Cardinal direction means norht, south, east, west directions and these directions we can code them and give some number like in this example we are giving for east direction we are giving zero for norht direction say anti-clockwise. So we are giving east zero, norht one, west 2 and south 3. So these are just simple codes one can while writing a program, one can change these codes there is no problem.

But just for our understanding anti-clockwise and starting from east and starting from zero value to three value are coded. And this example we start at a row 10, row 10 is this one, because on the extreme left that is the column one row 10 is the first pixel which has to be coded or

boundary of this one has to be recorded. So we start with the row 10 column 1 and the boundary of the region is coded clockwise by that.

So though the codes are anti-clockwise but the boundary will be coded clockwise. So this is how if we code it, this is not arithmetic that one we can argue about that how zero can have power 2, these are just codes, so assume not a numeric value, but codes here.

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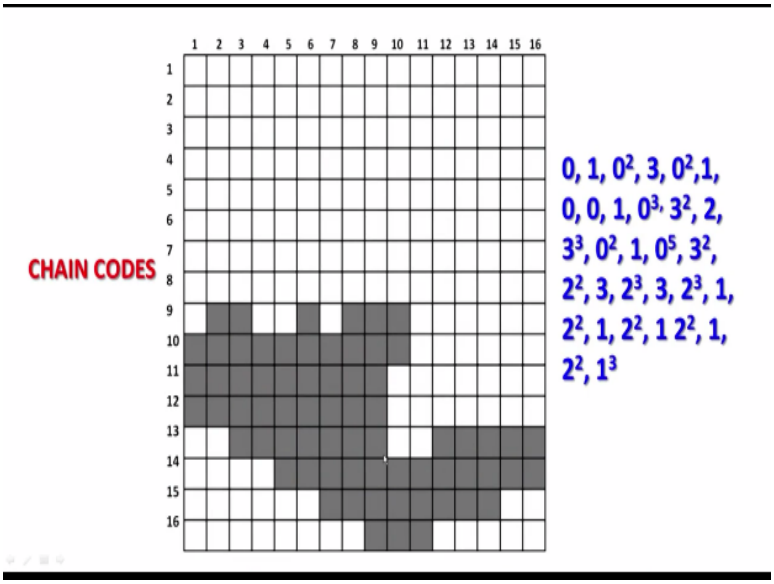

And so that if we say that zero that means one pixel and towards the east, because for east we have given zero code, for north we have given code one, so that is why first zero, this is the only single width pixel, single pixel width here. So one zero one, then now we have two, this boundary is having two pixels now. So and the direction is zero direction that is the east direction, so running in this one two pixels and that is why it is zero square.

Then that one pixel which is in direction of south, for south we have given code three, so the three is appearing. Then now two more in the direction of east, and east we have given code zero, so 2^2. And then one and likewise we continuously keep coding till we reach to end of this pixel. And here that is why 1^3 is shown here that for this one we are going up to this place, so because for north the code is 1 and the three pixel has to be recorded.

So now once we reach to this place the entire boundary, the shaded boundary is recorded and this kind of coding or this ind of compression is called chain codes. Otherwise, the system will if we

do go for compression using say this compression techniques which is chain codes, then each pixel has to be stored in the image, in the system. Now here only these codes are stored and well these codes are stored then you can go back and uncheck the things or decompress it. So this kind of thing are there.

See there are if you try to understand there are two basic kinds of compression techniques exist one is called constructive compression techniques and which are reversible that means I will explain further and another type of techniques compression techniques which are called destructive compression technique in which you cannot restore to your original image.

And the best example is like JPEG, JPEG is a destructive image compression, image format where if you have lost the original file like suppose you have taken a photograph or a satellite image which was in doctim format, TIM that is tend information file format. Now this format image you have compressed in JPEG format and you deleted the original file. Though the JPEG will receive compressed image formats, so you will occupy very little space compared to your original file.

But the quality will detoriate, so and if later on you rely that no, I did not want to loose the quality, I want to have the original quality image, then you cannot reach door wide, that is why we put them under destructive image processing techniques, average compression techniques whereas tiff, on tiff also you can apply certain compressions which we will see the example. And you can decompress it and you erach to the original thing like in win chip.

You compress anything text file, image file, audio file whatever in your harddisk and then later on you can decompress it and you do not lose any data, there is no modification or manipulation of your data. So that is why it is more popular, so once people understand then they will adopt the particular compression technique, for their requirement. So the first technique which is the basic type of technique which we have just discussed in chain codes.

Now there is a very popular compression technique which is also called RAB, run-length and codes for run-length codes. In this one it allows the points in each mapping unit and mapping unit is our pixel to be stored per row in terms of left to right and of a beginning cell enhancer, because the lcoation of the cell has to be also stored. And this in run-length codes if you want to say the same binary image if you want to coded then only these number of rows.

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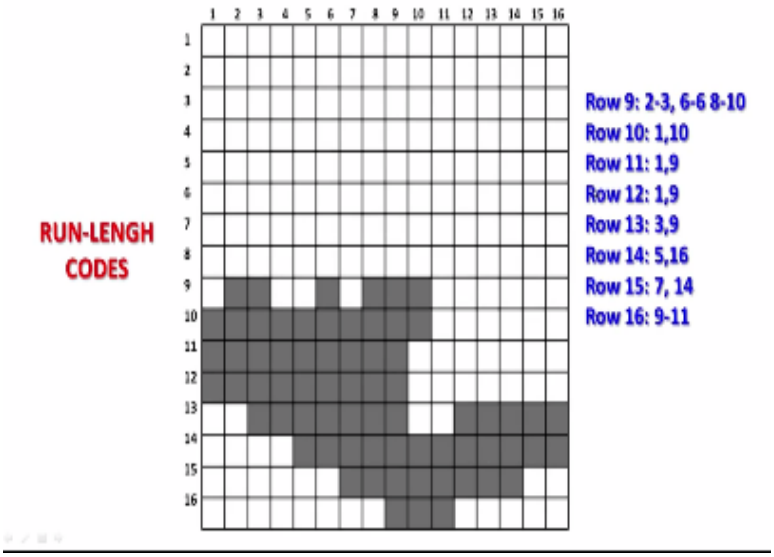

And we can in roughly just 8 rows we can store this entire image rather than 16 / 16 rows and columns so how in run length code is there as a this is we start with 9 because only on the 9th row we are having the back areas so 9th or shaded area so 9 and then run length along the from east to west sorry from west to east what sis the number of pixels and that is what is run length so that two pixel second two pixel three so these two are coded then there is a gab so the gab is left then 6 to 6.

That means only one pixel as to be coded and then 8 to 10 and less go for row 10, row 10 is continuously having the shade up to this column n so it is 1 to 10, same way the row 11 1 to 9 and so on do forth till you reach to the end last row and that low is 16 and the shaded area which as to be code is starts from column 9 and end at column 11, so likewise instead of storing the values for each pixel we store only in this example only 8 rows and length of the shaded area.

The 3rd type of third basic type of a block code is the compression technique is block codes and this is little complicated compare to the first to previous one.

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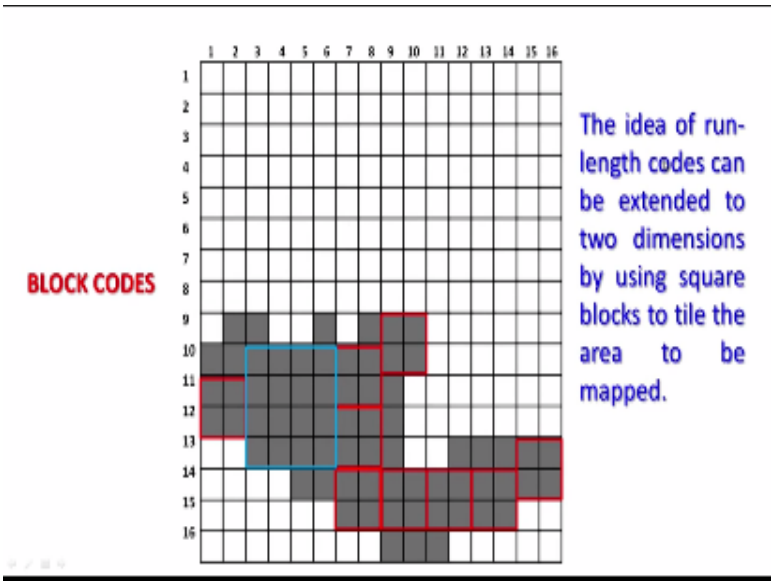

That the idea here of run length codes cane be extend to two dimensions because run length was just 1 dimension it starts from a particular row and then along the from west to east runs run the length but here instead of having that we can go for square blocks of titles and through which we can cover the area.

So what we are seeing here that here first the search is made where the largest square block can be used so in this example what we are saying that a 4 / 4 block square block can be coded here then there are many square blocks of 2/ 2 and then till you keep doing this thing till you reach to the unit level unit level here is just one pixel, so the rest of the or we can say blood blocks are just single block.

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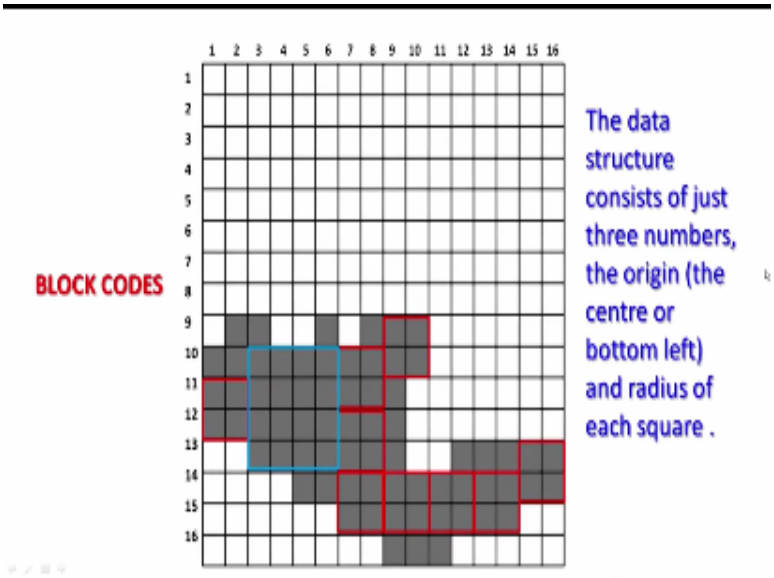

So let us see how the codes will look the data structure here consists of 3 numbers and for each block that the origin or center bottom left of the block and the radios means how thick or width the block is so 4 / 4 may be 2 / 2 may be 1 / 1 and this image can be coded very easily that the locations of block x and y definitely and there are what we see.

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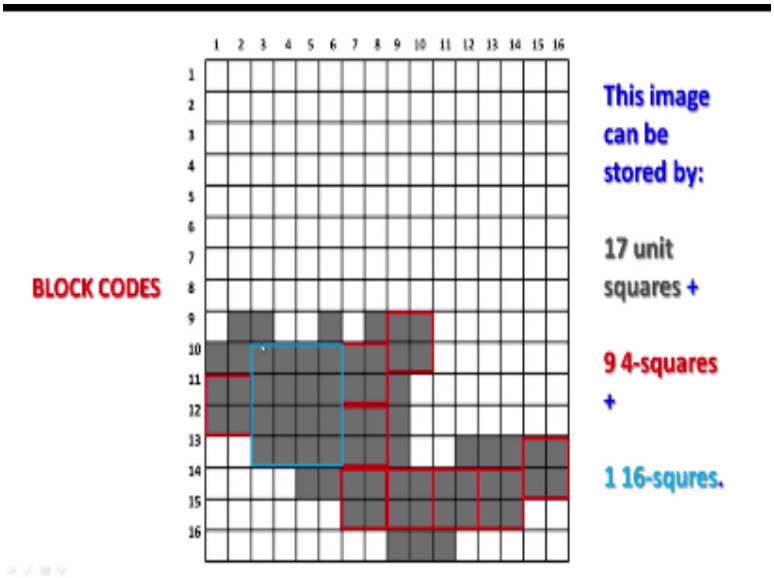

That there is a only one square having 16 pixels which is shown here in blue color plus there are 9 squares of 4 pixels that you can see so 4 pixels squares are there they total 9 and then there are 17 unit square so when you add up with this saying the entire shaded are or black areas as been

code of course you have for each block square you have to store the origin but instead of storing 16 / 16 pixel image in this through this compression technique the same area in this particular binary example which is very simple one.

And the only the shaded area can be stored now here more the homogeneity we find definitely we will achieve more compression and this is true in for all compression techniques if there is a that means if they sometimes there are lot of redundancy which is present in the data and that the redundancy is nothing but the homogeneous large homogenous area present in an image if that the situation is there then you can achieve very high compression especially like form back codes.

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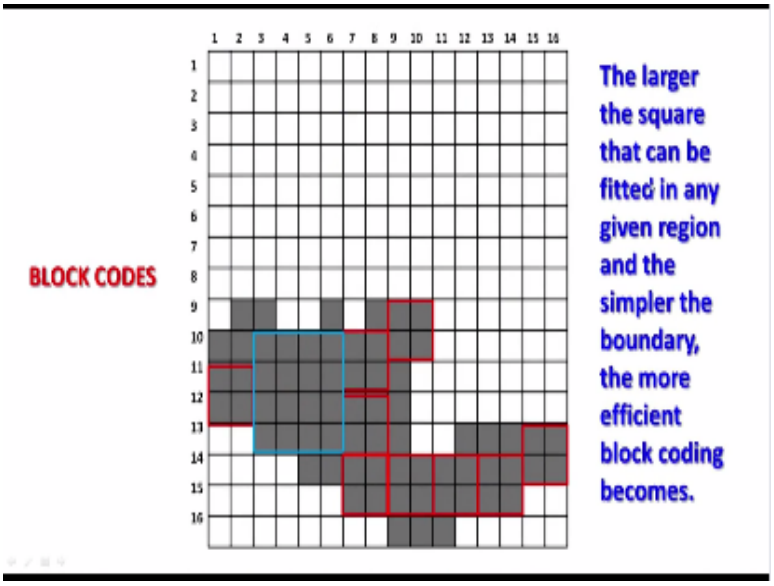

So the larger the square the square that can be fitted in any given region and the simpler the boundary the more efficient block coding becomes, so a homogenous because large homogenous areas if they are found in an image you will achieve very high compression and the 4^{th} basic techniques is called quadtree and this is more little complicated method but can achieve very compression it has been implemented in may image digital image processing's software's and there are various versions of quadtree like quadtree like coteries and so on the two have been implemented. So let us see what is basic required quadtree.

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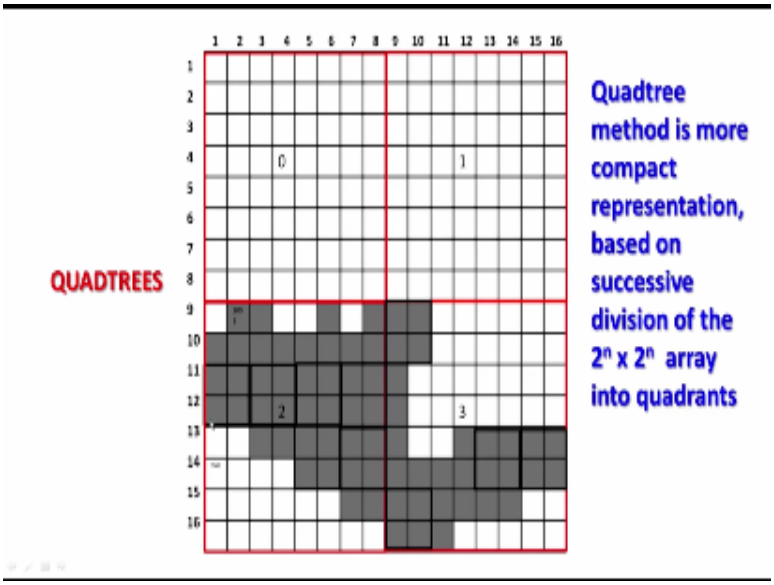

So quadtree method is more compact representation therefore it achieve more compression based on the successive division of the $2^m / 2^n$ array in two quadrants, so each area if it is most homogeneous then it is divided in 4 quadrants and this division goes on till you reach to the unit level, now in this example we have taken a 16 / 16 pixel binary image what we are seeing here that in order to code this shaded area first is whole image is divide into 4 quadrants and 4 codes are assigned to each quadrant for this north west quadrant 0 value is assigned for4 north east quadrant one value is assigned for south west quadrant two is assigned and for south east quadrant three is assigned.

Now this coding for different quadrant will continue till you reach to the unit level unit level here is our pixel, now after dividing into 4 quadrant the search will be made weather we have achieved the homogeneity within the quadrant or not if yes then further divisions will be required and if no then further divisions are will be required and if no then further divisions are required

so in case of quadrant 0 quadrant 1 no further divisions are required because we have reached the homogenous area.

There are no black areas all pixels are having same value width value or 1 value rest are may be 2 other quadrants are having some pixel which are having 0 value because we are taking example of binary image now let us go in the quadrant 2 that is the south west quadrant her we find there is a we have not achieved the homogeneity so now this quadrant two will be further divided into 4 quadrants and the coding scheme will be the same as the done further first 4 quadrant.

Here so again the north west quadrant will get 0 but that would be the second digit and therefore if you can see this is two 0 and further 0 and 1 how these have I will explain little later, so this has been the quadrant two the large quadrant two as been divided into 4 quadrants and then again search is made after coding and if homogeneity as not achieved then further division is required so in case of say I take this example of 00, the quadrant 00 then further divisions are required now out of these 4 quadrants this quadrant will have 00 now here and quadrant 00 is still having hextogenity.

So further 4 divisions are required and now we have reached to unit level and therefore this quadrant is having two 00 1 where as this quadrant would have the code 2000 and likewise you keep making divisions or divisions in form of quadrants till you reach to the unit level there might be a question here with scenario that it is mentioned in this during in this course duration of this course.

That a unit of an image or raster as to be square shape but the same time it has also been motioned that the overall shape of an image can be either square or rectangle so if we remember that one then all that time all images will not have a square in shape we can have an image which may be rectangular over shape of the image may be rectangular so how this then quadrant we applied. So that example we leave little later and why it is called quadtree then we will see.

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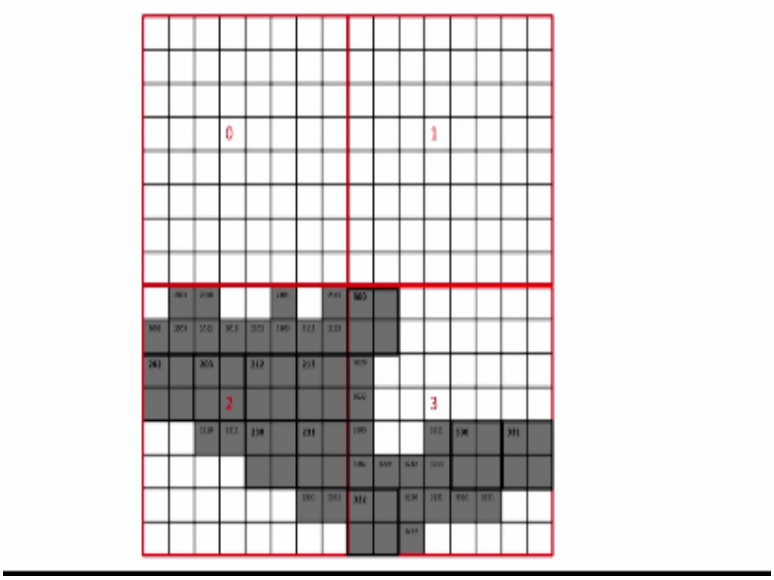

So now each these this have been coded here as you can see very well so once the homogenizes achieved in any quadrant no further division are required.

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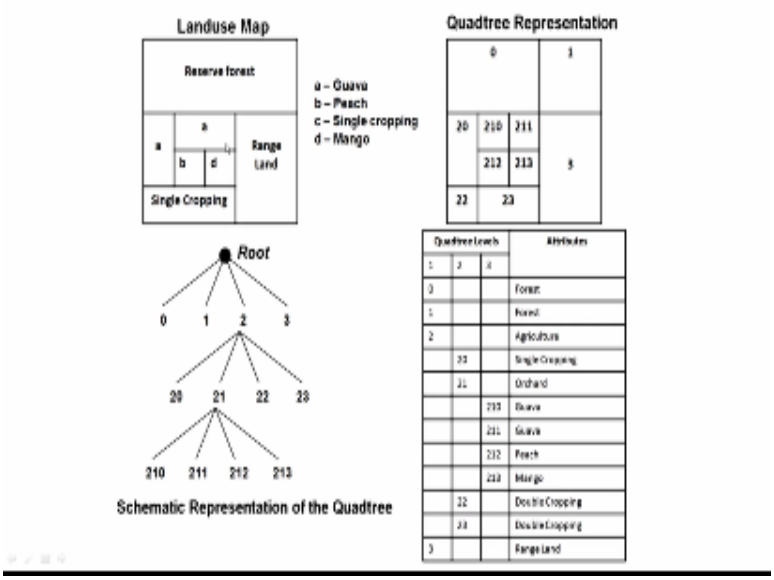

So quadtree because you first you divide in 4 quadrants so it is nothing but inverted tree kind of concept and like here that 0123 it is realized that quadrant 0,1 and 3 have reach homogeneity no further divisions are required where as quadrant 2 requires the divisions so then again 4th quadrants again 2 , 1 quadrants 2, 1 requires further divisions so the it as gone to the 3rd stage of division and this is the example here which I have just mentioning that is not necessary that image should have only a square shape it can rectangular shape the example here is deliberately it is shown here that the division are being made like this.

So here also we are sort of square in this quadrant we are also sort of a square in this quadrant also and that means the image has to be extended and this is how we achieve the concept of n^2 image which is the pre-requisite of your Quad tree.

So we extend the image for the through the software the image is extended so it becomes a square in shape and then Quad trees are formed. So here the example every block has been coded here 0123 and then in the 2 further divisions are required so on this side it has been extended so this is the you know center of that place where divisions with this is a quadrant 1 so that becomes 21 and then further division so it is 210 and likewise.

And you are having quad tree levels first whether it is first level, 2nd level, 3red level this tree is here the table is 1 here and different types of either here instead of having binary now we are having multiple types of units on there, this still it is schematic kind of a image or a very simple

it still very simple example but in real one also where you are having various types of ground features present in image but still quad tree can be performed.

So quad tree might take lot of time compressions but it provides a good compression and further you can any time achieve to the original image so this is completely a destructive non destructive image compression technique. As I also mentioned that there are various compression techniques which are associated which are suited for certain kind of image formats, for example TIFF so for a tiff images can be compressed using LZW compression. What is LZW?

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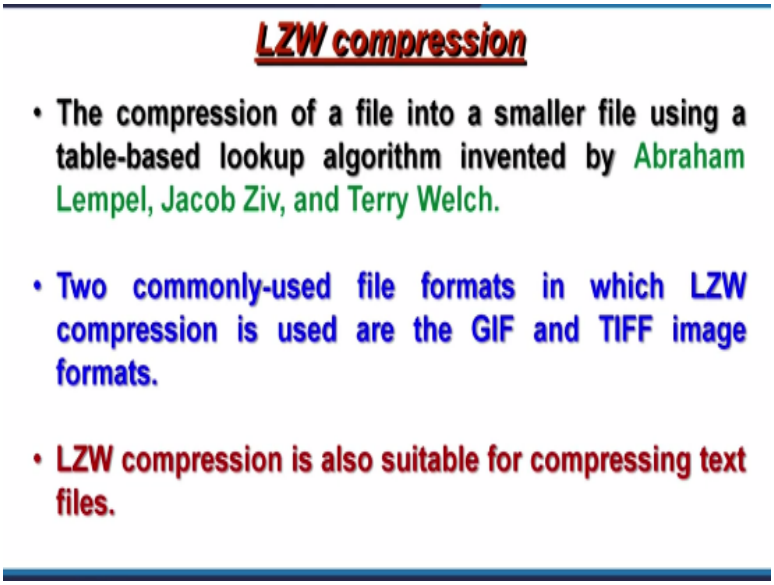

Basically it was developed by 3 mathematicians Lempel, Jacob Ziv and Terry Welch and these the first corrector of their names have been take so L, Z and W here so LZW compression which this file into a smaller file using a table base lookup algorithm which was invented by this is a still a non destructive image compression technique so your tiff file may be jiff file can be compressed using LZW very common have been implemented in various image processing software.

And you can reduce the occupancy on your hard disk by a large image high ratio spatial resolution image and then many image processing operations can be performed even when your images compressed with LZW that is the another advantage with LZW, so the two commonly used for file formats in which a LZW compression can be preformed and can many operations digital image processing and still be operated without decompressing it which are the formats

which are suitable for LZW compression as I have mentioned in jiff and Tiff file format. And this compression is also suitable for compressing text files.

Generally text files do not have much redundancy but if somebody else create it and lot of blank pages in your text file that means lot of redundancies available and therefore you may achieve something, so here is one example from one a public domain.

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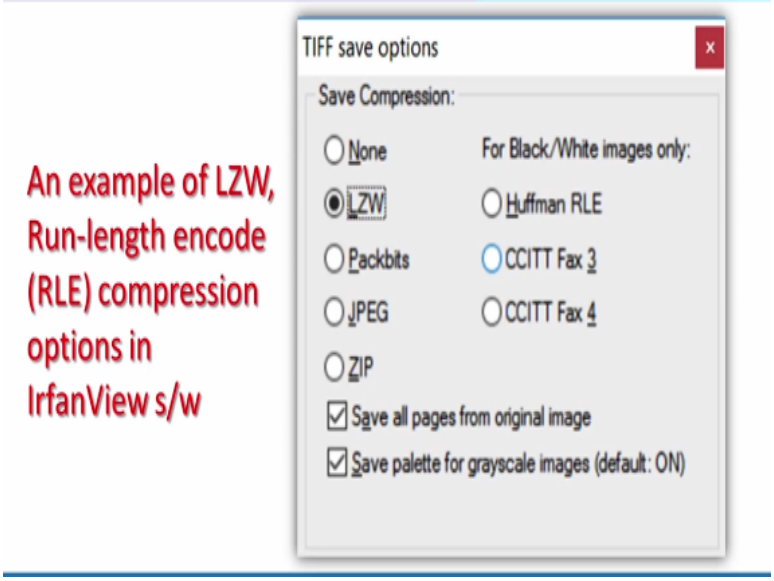

Software which is called a Irfan View and I am showing that a file it was original file was in tiff format and now I can choose the image compression format which is LZW and once I choose this one there are other compression techniques are also available like RLE which is nothing But the run length codes or run length encoding this is the same way and same technique run length encoders will be implemented JPEG is there, pack bits is there and off course our very common compression tool ZIP is also there.

But as I mentioned the advantage with LZW compression that even image processing various image processing operations can be performed on LZW compressed images so that is the biggest advantage, now there are JPEG.

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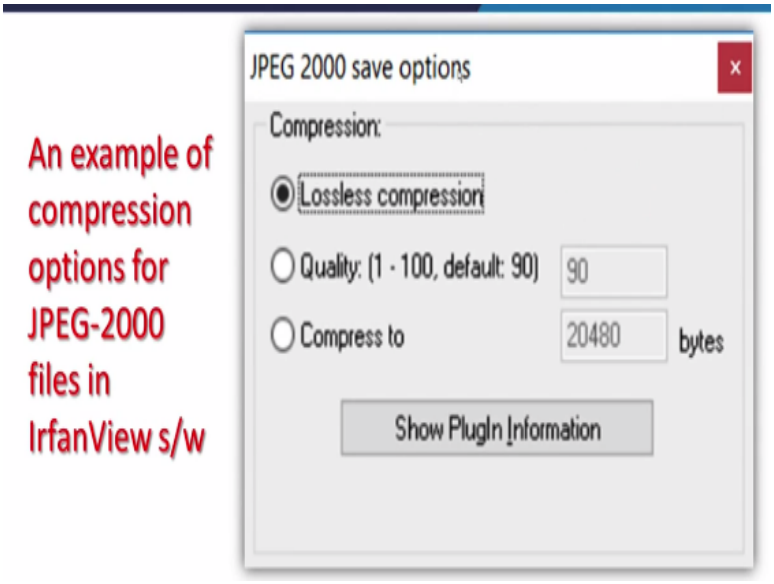

Example here the original image in JPEG so we are having this options these options again is shown in through this software Irfan View that lossless compression that means you do not lose the quality of image and therefore there will not be any need for you to keep the original file, so there are possibilities of lossless and generally the options which we go for JPEG are full of loss so we use the quality but the same time we achieve a very good compression.

So is a trade off, you want to have a very compact file size or you want to have a good quality image, this is very iron in that people are going for higher and higher mega pixel mobile cameras but the same time they store or they originally take images set their images in JPEG format and JPEG format is not really non destructive it is destructive image format. So in some way the investment which they are making for quality of image they are not achieving if they are saving the images in JPEG format.

Instead they should save if of suns allowed your operating system allow when we save it as it if and then you can do this experiment save the same file in TIFF format original file then save as JPEG and then join any common part which is on the both image you would realize after certain zoom in that there is definitely deterioration of quality in JPEG format, nothing comes free is a trade off you need achieve a very good compression but the same time you lose the quality. Buts sometimes because of for the transmission requirements through sending through net or making a storage we go for JPEG as well so LZW compression algorithms.

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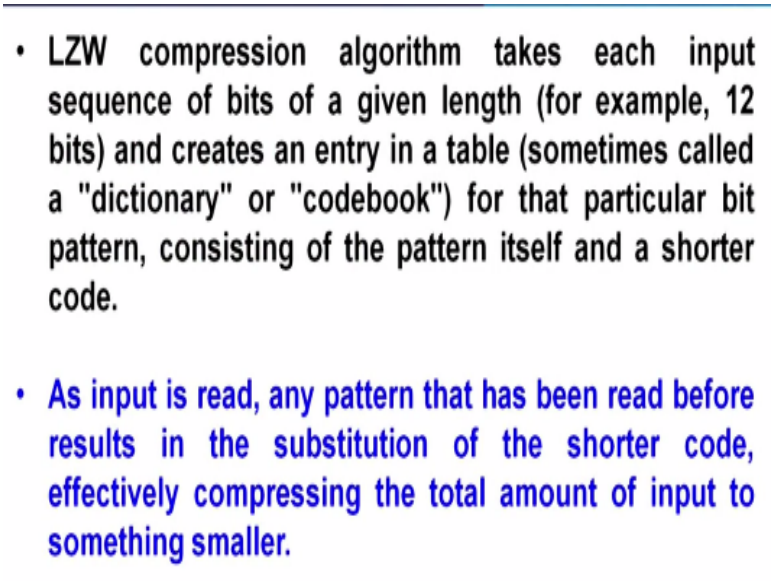

Takes each input sequence of bits of a given length for example 12 bits and creates an entry in a table as I mentioned look up table kind of thing or codebook for a that particular bit pattern consisting of pattern itself and a shorter code, and the input is required is red any pattern has been red before results in the substitution of the shorter code effectively compressing the total amount of input to something smaller and that is why compression is achieved. And like there are various versions of LZW are also same level like LZW which was developed in 77 then the modified version upgraded version 78 then other one is also LZW algorithm does not include look after will of course as per part of compress file.

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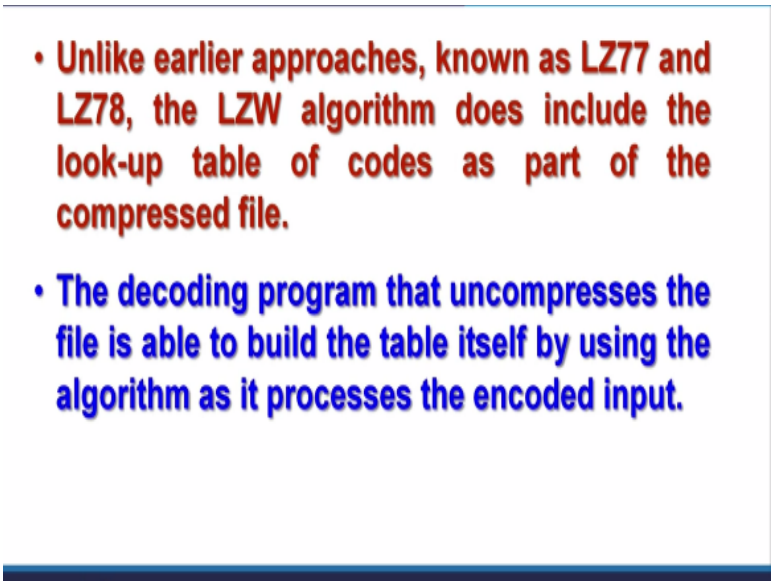

And decoding pattern program that uncompresses the file is able to build the table itself by using the algorithm as it processes the encoded input, so the decoding or unnecessary JPEG inbuilt basically now this JPEG which is in ISO group of experts which is called Join photographic expert group have developed and there are various versions of JPEG are also there and which is JPEG is also term for any graphic image file.

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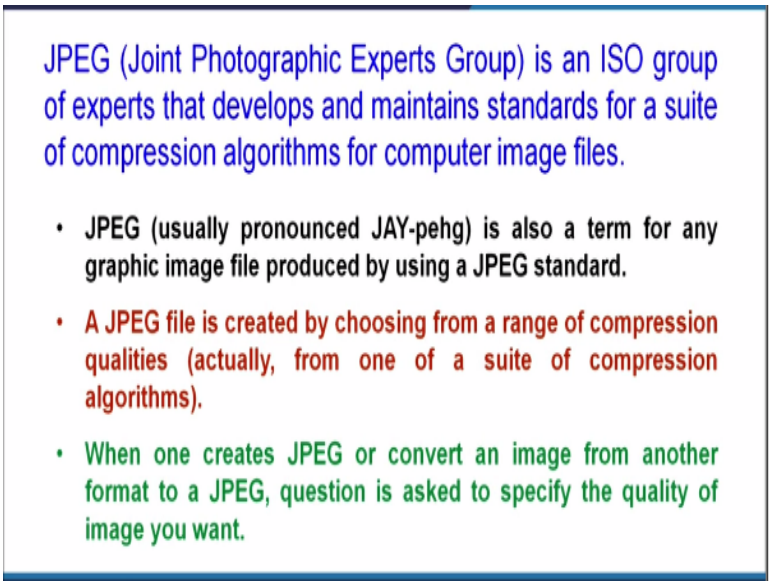

Produced by using JPEG standard JPEG file is created by choosing from a range of compression quality you can choose or you want to have a 100% quality or 50% quality and then accordingly the compression will be performed and when one creates a pack or convert and image from another format to JPEG so JPEG is a compression techniques same time image format elsewhere. And question is ask to specify the quality of image and since the highest quality results in the largest file.

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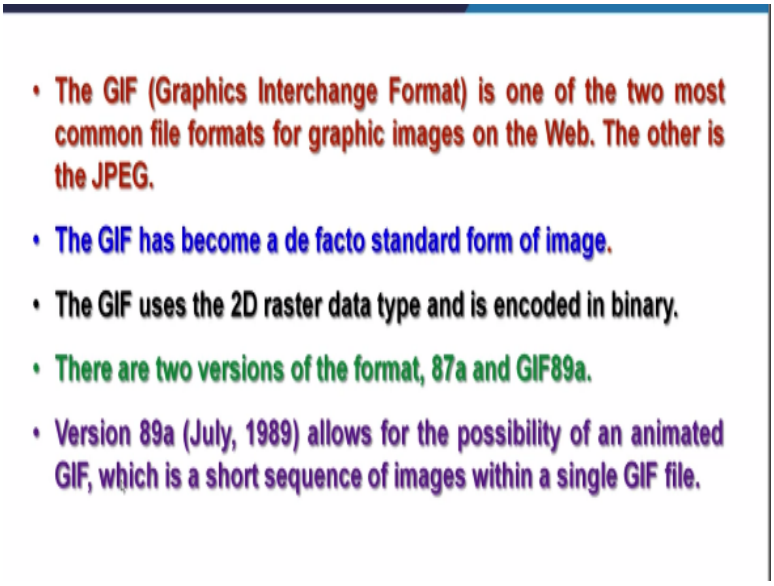

You can make a tradeoff between image quality and file size so you have to asses that whether you want to retain the quality of an image or you want to have a high compression and accordingly things are chosen, there is another formats which are still popular and which is a JIFF format, JIFF basically graphic interchange format but mainly its is used for animations and there is another format portable network graphics versus PNG format various format exits.

All none is universal or non is the best there are some advantages and there are disadvantage like tiff, tiff is good but it occupy lot of space JPEG is good from point of view of hard disk space but it deteriorate the quality of your image, so these are the common formats on the web your JPEG and JIFF and has become defective standard form of image, GIF uses 2D rater data type and is encoded in binary, there are two versions of the format 87a and GIF89a.

And version this allows the possibility of an animated graphics so if you are having sequence of frames you can put a time gap and can create a set of moving or animations which are becoming very popular, one example here I am showing.

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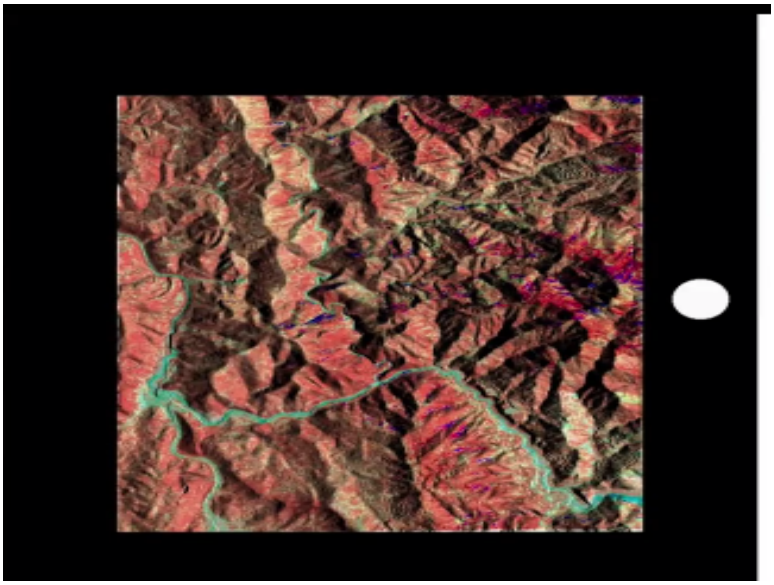

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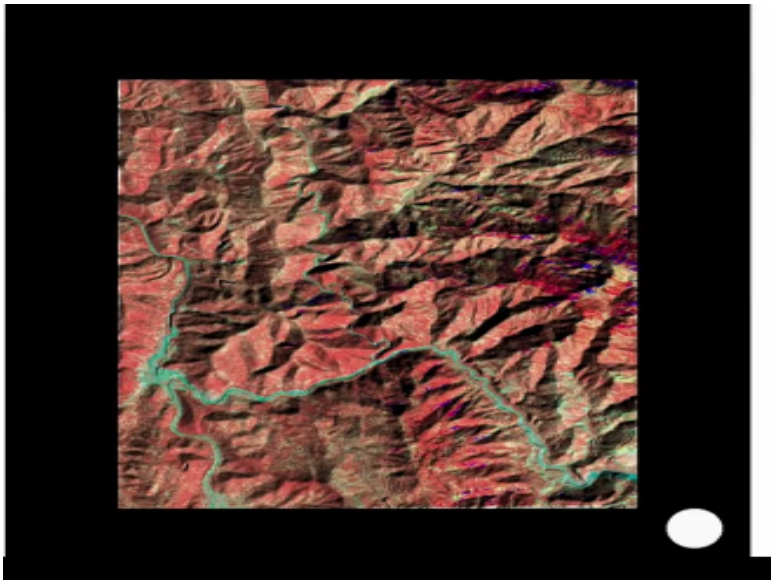

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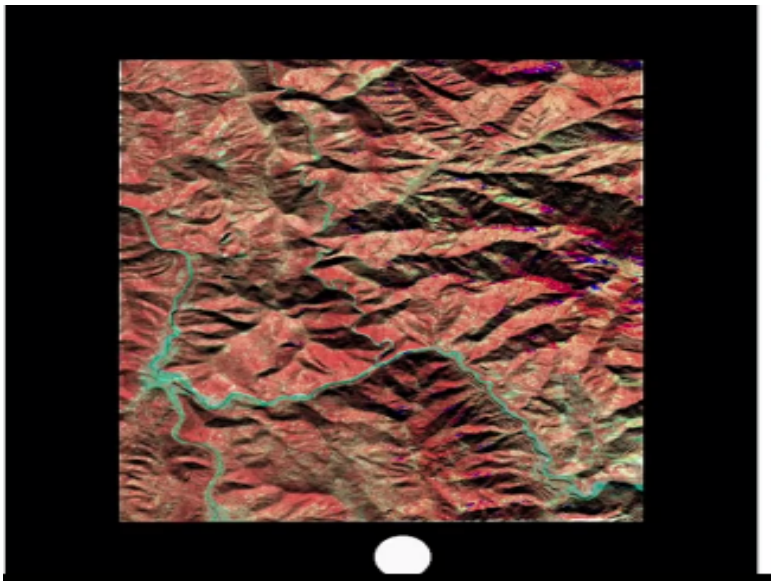

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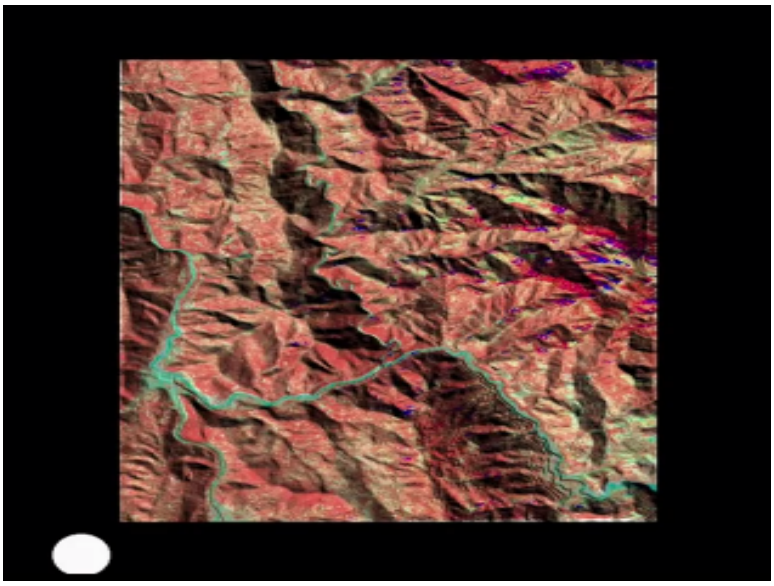

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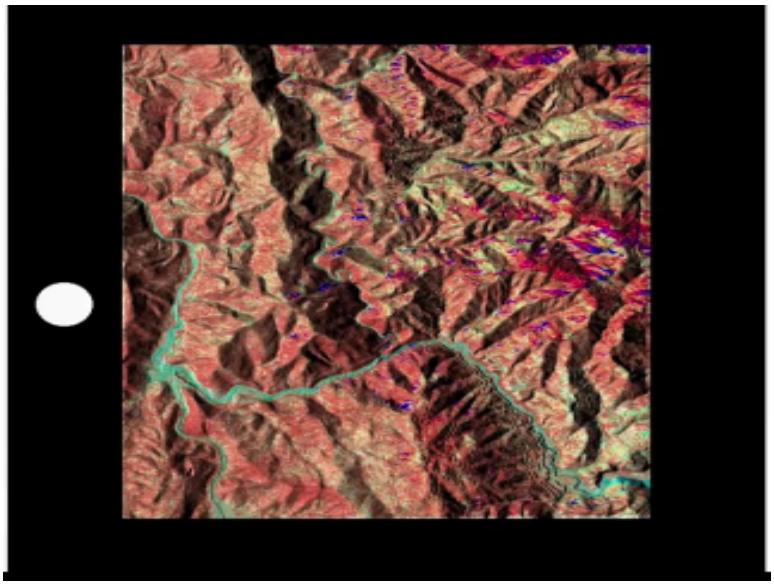

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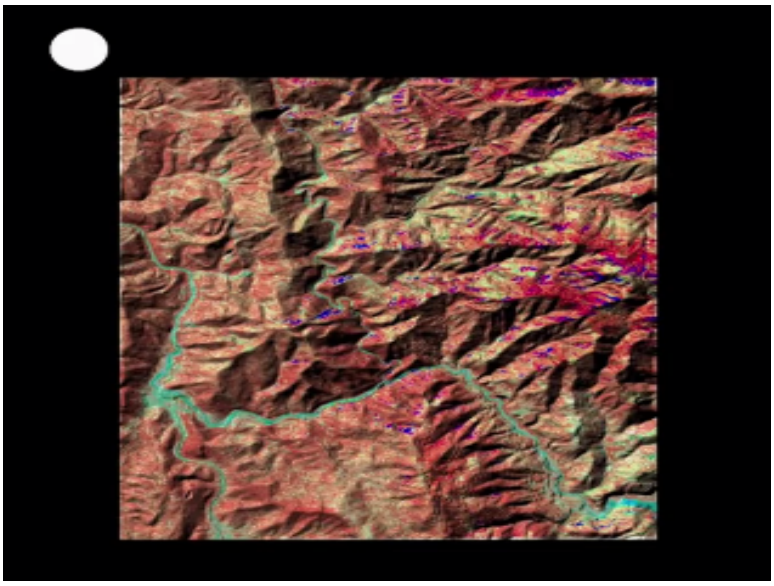

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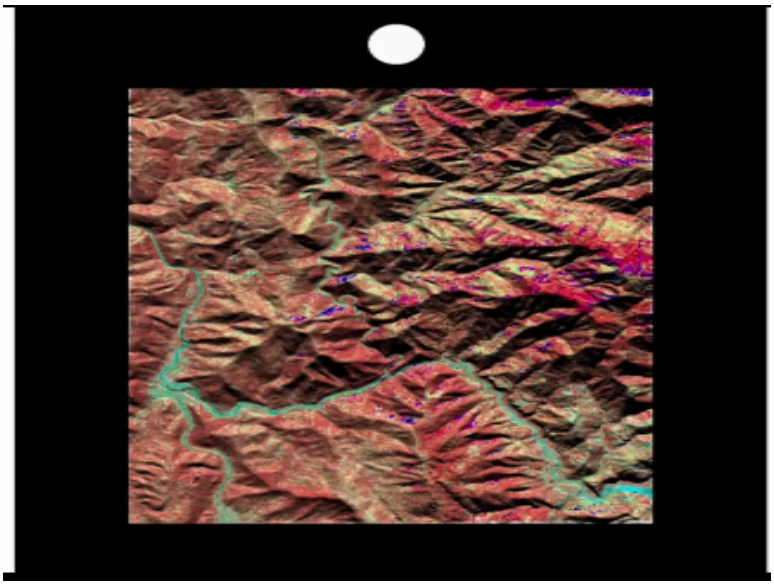

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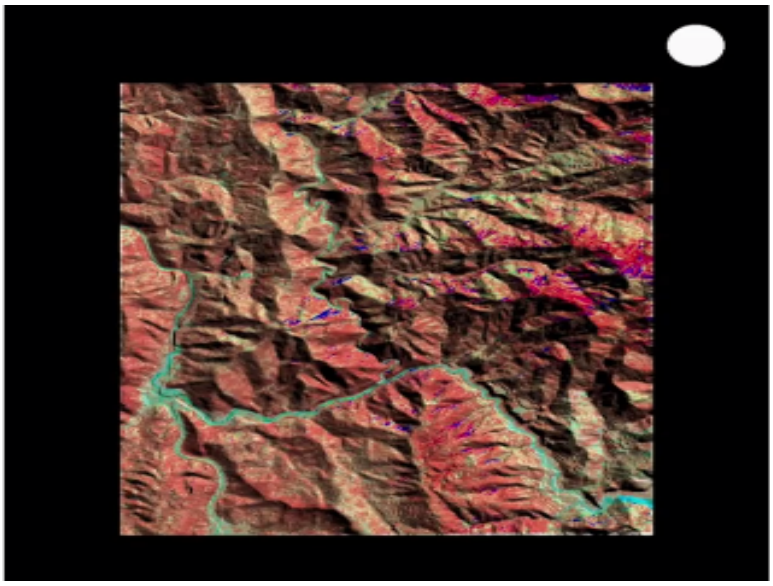

There are 8 images created from different 8 directions through for certain purpose to remove a false to pornographic perceptions phenomena and 8 illumination position of the sun is there and then all these 8 frames of the same size have been put in a JIFF file and through some utilities like JIFF creator and other things and it becomes a animated file so single file will have eight frames with the time gap for changing from frame one frame to another is depending on the user how first you want to change these frames or how slow you want that you can choose while wielding up the gif file through utilities like gif creator and many such things are there here also that illumination.

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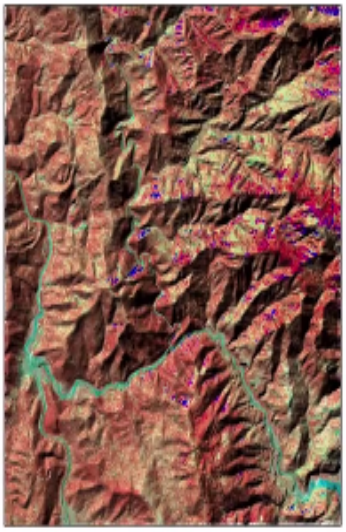

Of the sun is starting from horizon it goes to overhead so there are where about 10 images in for different angles or rather and then you see they are been put in a sequence with the time gap here this is in the previous one it was little slower and change in the frame here it is little faster so that time between two frame change is maybe few seconds and there it was much larger and therefore a single file will carry a kind of movie, so these are animated files.

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This is interchangeable and it is a patent free so there are no copyright chosen other things.

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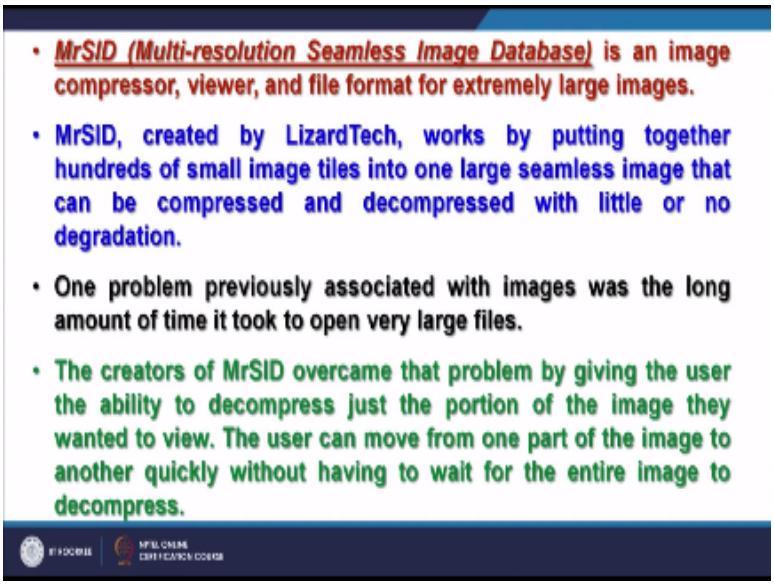

Now this another image format which is very popular for large images and which is Mr.SID which is multi resolution seem less image data base and this compression is really very, very powerful this has been created by company which is called LizardTech and it can compress a 15MB file into 1MB and this is completely nondestructive image file format compression technique. However details are not known because it is copyright protected.

So one problem previously associated with the images was long amount of time to took to open very large files. So what we do we compress our images and then we can display these images very quickly and like Google earth images are having this kind of compression, so when you display even high revolution image the display is much faster because this compression techniques have been employed there.

So the creators of MrSID overcame that problem by giving user the ability to decompress just the portion of the image they wanted that is it is called multi resolutions seem less image creation or image data base, so as you keep zooming an image like in Google earth we keep doing first we say looking Hindi over India then we keep zoom and then maybe Uttarakhand, maybe in within Uttarakhand, Haridwar district then Roorkee IIT so as keep zooming we are going higher and higher in that kind of pyramid. And we are seeing multi resolution images are coming, and they all have been put in this MrSID format.

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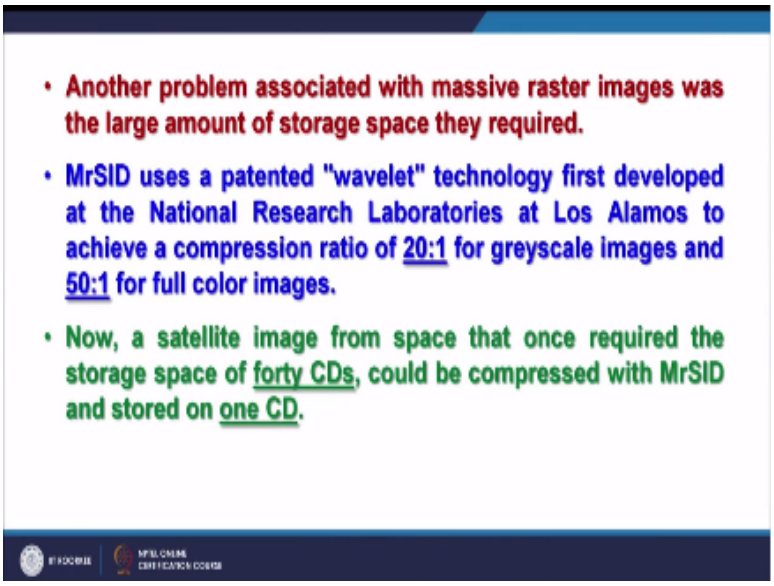

So another problem associated with massive raster data images was the large amount of storage space they require. Now assume that in many change detection studies some of them we will discuss just for an example here in maybe in little later in different lectures, that nowadays since 1972 onward remote sensing data that is landslide MSS still the landslide well I sees of landslide series data is now available on net.

Similarly other satellite data are also becoming available free of cost on net and therefore lot of change detection studies are being done, can be done and in order to do these studies we have to handle large amount of data and therefore the requirement of very efficient data compression techniques which should help us for first fast display which should help us to occupy very less space on hard disk requirements of such compression techniques has really become use nowadays.

Because of the handling of data is also very large nowadays because of free availability or data. So people are looking for different the MrSID is based on the patent trade wavelet technology, first developed at NRL at Los Alamos and to achieve a compression ratio of 20 to 1 for grey images and 50 to 1 for full color images, so 50 MB image maybe compressed into 1MB image it depends again on the homogeneity or redundancy image.

So now the satellite image from space that once required and the storage space of forty CDs could be compressed with MrSID and stored on only one CD, so that kind of compression is there. Another concept which is not exactly compression but it is, it improves our display of

images on a screen through a image processing system and that technique is called pyramids. It has become very popular and many digital image processing software even the GIS softwares have been implemented.

Like for example, RGIS they two have implement so whenever you try to display a raster image first time it will ask automatically, do you want to create pyramids and if you say yes, then it will create too very small files, these small files are keeping the structure of your pyramid and this is allow again the same thing that as you zoom a higher resolution image will appear you keep zooming you get more further and further details.

If you zoom out then you see lower and lower resolution, so this pyramids allows very good, this is a very good to facility which is has now available in popular image processing in GIS softwares.

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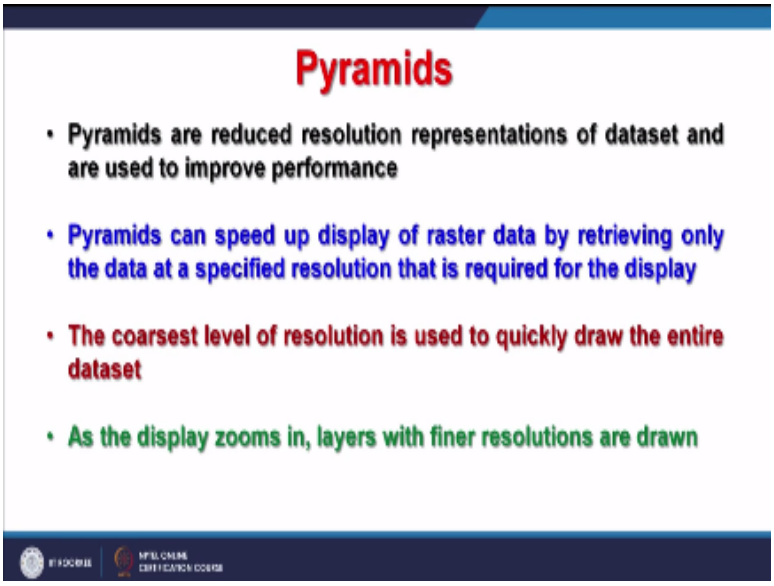

So pyramids are reduced resolution representations of dataset and are used to improve performance to in the display, and pyramids can speed up display of raster data by retrieving only a data at a specified resolution, if I am looking in the middle of the thing that means in the pyramid I am the middle I will see only the middle resolution image not the high resolution image at middle stage.

So the coarsest level of resolution is used to quickly draw the entire data set on the display. As the display zooms in layers with finer resolutions are drawn.

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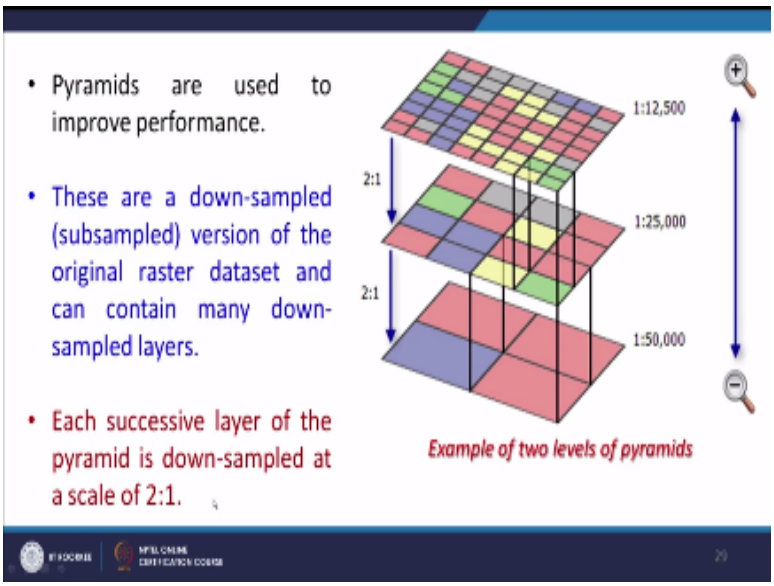

Pyramids are used to improve performance, because ultimately we want to quickly see the image and this is how it is done that at different scales are also shown here, different resolution image of the same area is shown and once you offered to construct a pyramid then this is how the pyramid is constructed. So pyramids are used to improve performance these are down sampled version of original raster data set so at this is scale you are having down sampled it is that means

thus it is sub-sampled data so only the coarsest resolution image will first appear when you are looking for a large area.

So that is why it is original raster data set and can contain many down sampled layers and each successive layer of the pyramid is down sampled where a scale of 2:1.

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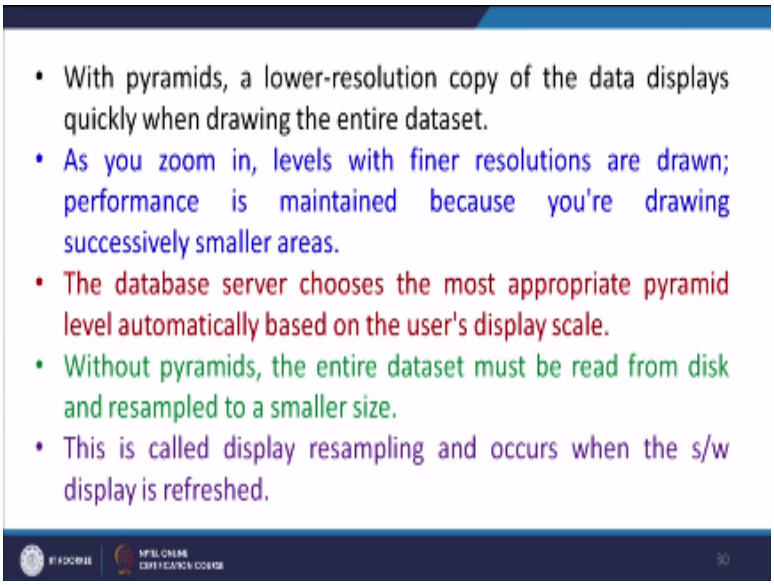

With pyramids a lower resolution copy of the data displays quickly when drawing the entire dataset. And as you zoom in the finer resolutions are drawn performing is maintained because you are drawing successively a smaller area, so you are zooming in you are reducing the require, you are covering the less area but higher space resolution, so the data base server chooses the most appropriate pyramid level automatically based on the users display scale.

So as you zoom in the scale is becoming larger and high resolution data is being displayed without promise the entire data set must be red from the hard disk and resample to smaller size and therefore lot of time is taken. So pyramid is a good for making a display much faster so this is called display re-sampling and occurs when the software display is refreshed, so whenever you

need such softwares ask you first time when you are displaying an image would you like to construct a pyramid you say, yes.

It will take few seconds to construct the pyramid and it will keep two separate files along with the same name but different extensions of the image and then next time whenever you will display the image your display would be much faster than the original image. So pyramids only need to build once as I have mentioned per raster data set at the very first to display time after that they are accessed each time the raster data set is viewed.

Here this word raster instead of image because you can also apply on your digital elevation models, so in digital image processing we are mainly focusing on remote sensing data so instead of raster you can say the image data sets and the larger the image data set the longer it takes to create the set of pyramid, of course if the file is very large it will take few more extra seconds but does not take much time this means you will save more time in long run.

So next time when you will open image file a large image file you will get in message on your screen then would you like to create a pyramid.

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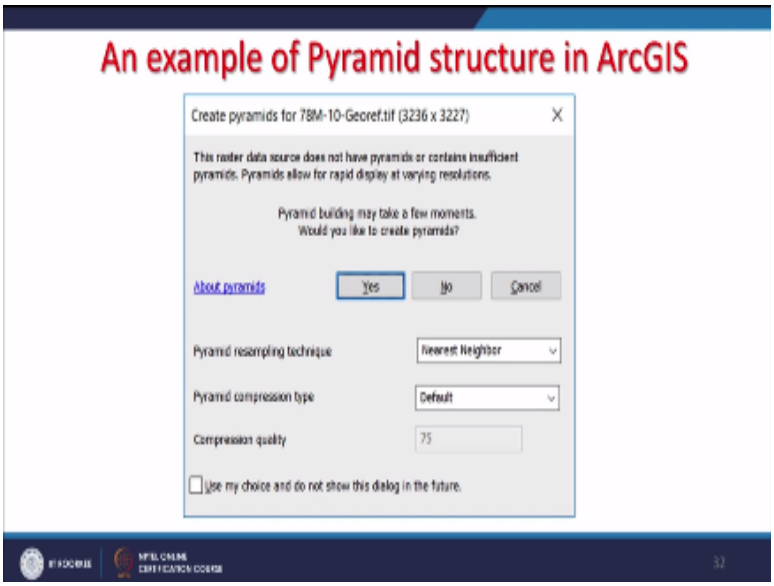

If you choose yes then it some options are also there even if you go for default there is no harm still it will your display will become faster, because these re-sampling techniques nearest neighbor bilinear and cubic conclusion are the same re-sampling techniques which we have

discussed while discussing the last and third step of your geo-referencing, so the same re-sampling techniques have been employed here as well.
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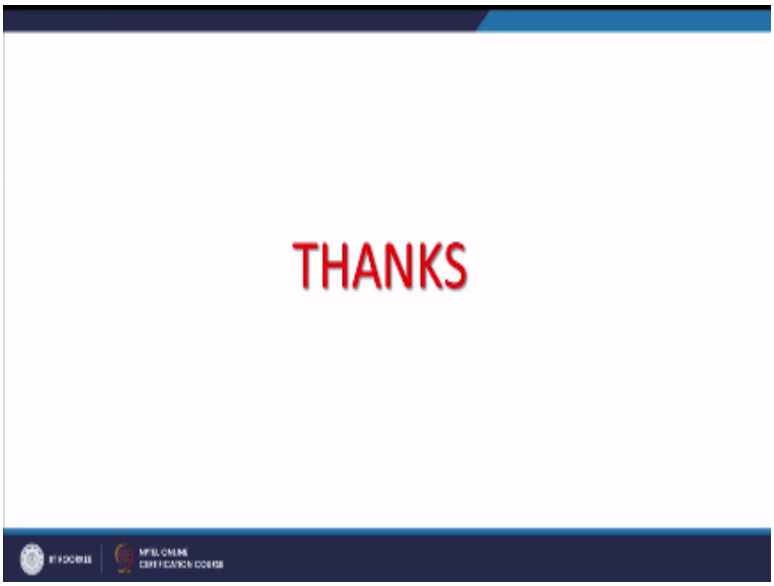

And this brings two end of this raster data compression techniques four basic compression techniques we have discussed there are various other compression techniques details of some of them are not known like your MrSID format which is copyright protected though we know that it is based on wavelet concept and there are other approaches like pyramids which we have seen that how advantages it becomes for displaying the large image.

Son depending on your requirement and one should choose but whenever you are choosing a image format my suggestion as per my experience would be choose that image format which is none destructed. So that any time if you want to restore the quality original quality of the image you should be able to do it without much problem, thank you very much.

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