Remote Sensing essentials
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Lecture-16
Importance of Digital Image Processing

Hello everyone, and now we are in the fourth week of this remote essential course. And today we are going to discuss the importance of digital image processing and how you know the images which are in digital form from acquired from satellite can be improved and what are different softwares and other things that we will see. So, in sort we also call as the image enhancement, as in previous lecture we have finally discussed that how image is acquired by a satellite earth station.

And then now we start about the digital image processing. So, what are the importance or important things about the digital image processing. Basically is a process which makes an image a interpretable for a specific use.

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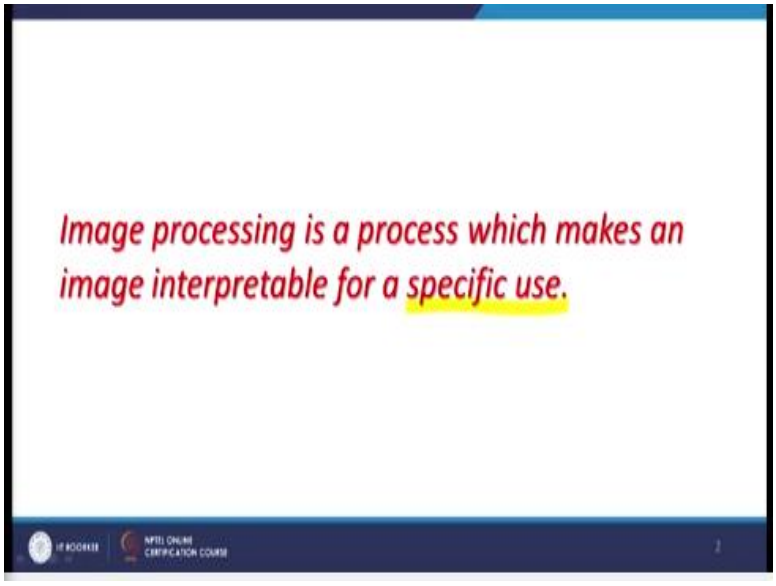

So, as as also we have been discussing that satellite images are generic and therefore, they can be used for various purposes starting from meteorology to agriculture. And therefore when we analyze or process these images, we have to keep in mind for what purpose or for what that is

specific use, we would like to use it. So, once that is clear, then images are processed accordingly and they finally, ultimate aim to identify different features present in on the image.

So, they are more interpretable that is the main purpose here. Now, there are 2 major task which are done in image processing. And the first one is the improvement of pictorial information basically the quality. So, that a human interpretation can be done in a better way because the images which are acquired by the satellites are completely raw images. And the when we start using them we need to improve otherwise it becomes very difficult to you know, use them for certain purposes.

So, the picture pictorial information, because after all a human interventions would be required, human interpretations would be required on those images. And the other thing is the processing of a image data for storage, so there are different levels of processing. And of course, the transmission maybe transmission from satellite towards the earth and maybe transmission from after the data has been archived by the earth station.

Then transmission to other computers situated in different parts of the band for further processing.

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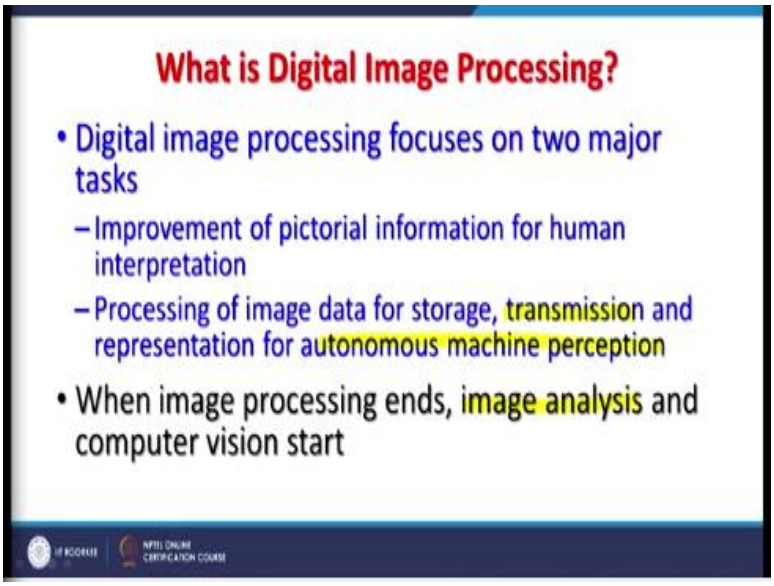

And then representation of whatever the autonomous machine perception that can also be done in the processing under this processing of digital image processing. And when image processing ends, basically the image analysis and computer vision start. So, initially some simple tasks are performed on image processing.

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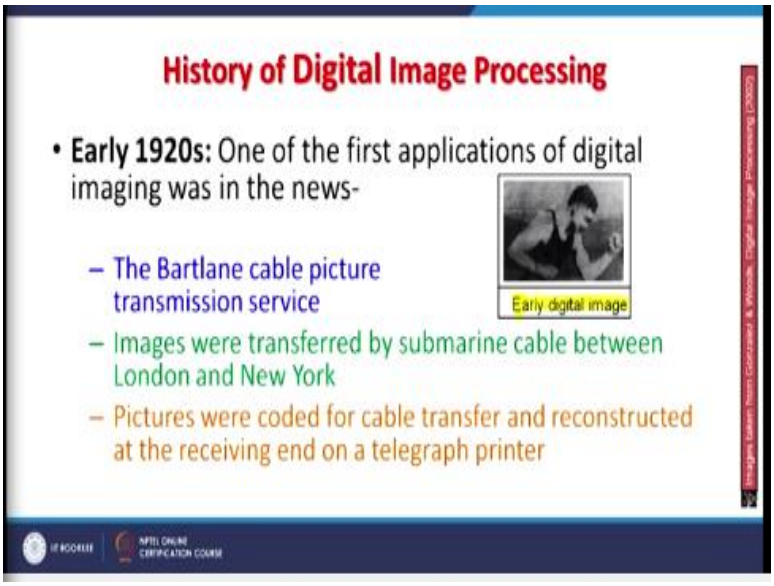

If I take the very early examples, which are not images from the satellites, but they are basically photographs. Now after scanning these have become a digital photograph, so in early 1920s one of the first applications of digital imaging was in the news. That is the our new digital image was there in 1920s, as a runner is there and Bartlane cable picture transmission service that was done.

Images were transferred by submarine cable between London and New York which is having a very long distance. And the pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer. So, you know at that time lot of things were required to be done before image is either printed or displayed on the screen. Now, these things have significantly improved and now we get live transmissions of high definition images on television very easily.

Same way also we get direct the images by the satellites, if one is having their own satellite earth station. So, these transmission and you know coding and then transferring and then reconstruction everything goes simultaneously and at a very high speed.

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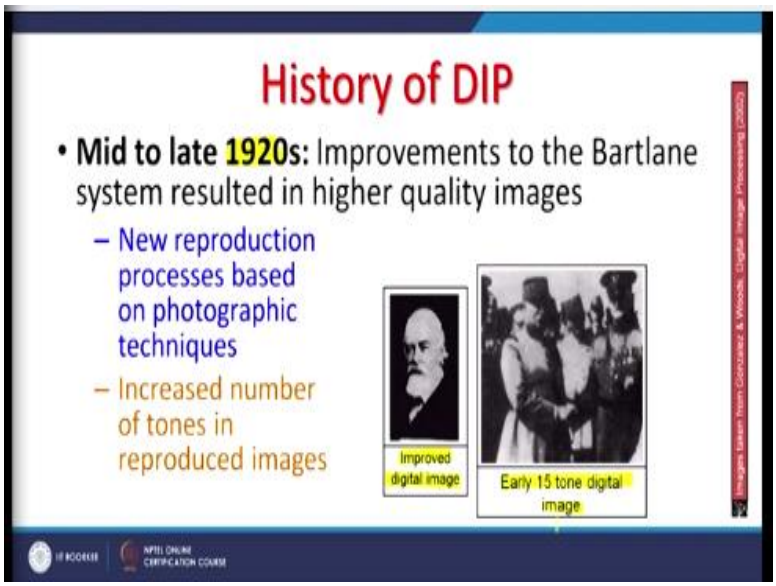

So, if we look at very briefly the history of digital image processing, so, as soon as the digital images became possible or available, the processing also started at the same time. So, in the same in the 1920s the improvements to Bartlane system resulted in higher quality measures. And, like this example is that this was improved digital image.

And earlier we had only 15 tone digital image means there were only 15 sets on including to black and white and rest were and like that, so 16 kind of thing. And a new production processes based on photographic techniques were also evolved. And increase number of tones in reproduce images, tones here when we say tones in terms of digital images, we are talking about the quantization or radiometric resolution or how many bits are being assigned for one cell or one pixel.

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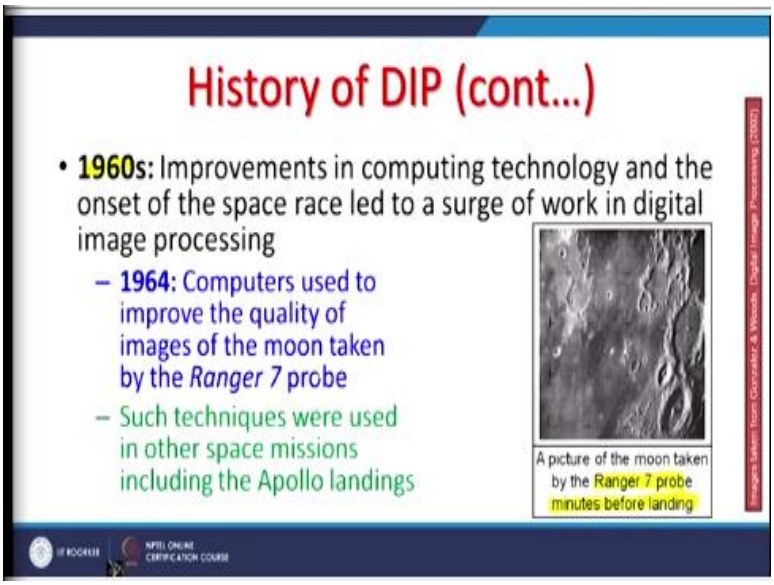

If we look the picture of moon taken by Ranger probe minutes before it is landing, this was the time the picture was there, that is in 1960s. Of course improvement lot of improvements have taken place not only in the computer technology but also in the sensing technology. And very soon on the 7th of September this year, we are going to see almost same kind of thing by Chandrayaan 2.

And there will be a robor which will land on the southern pole of moon and then of course will be doing probe as well. And we will be having live transmissions on our televisions. So, see that how things have improved very significantly since 1960s. In 1964 computers used to improve the quality of images of the moon taken by Ranger 7 probe.

And such techniques were used in other space missions including the Apollo landings on the moon surface. So, you know development in one sphere of science the same the developments are percolated also in the other domains. Like for these moon missions and other things, when the image processing is started, the same image processing, were improved and now we are seeing much better images.

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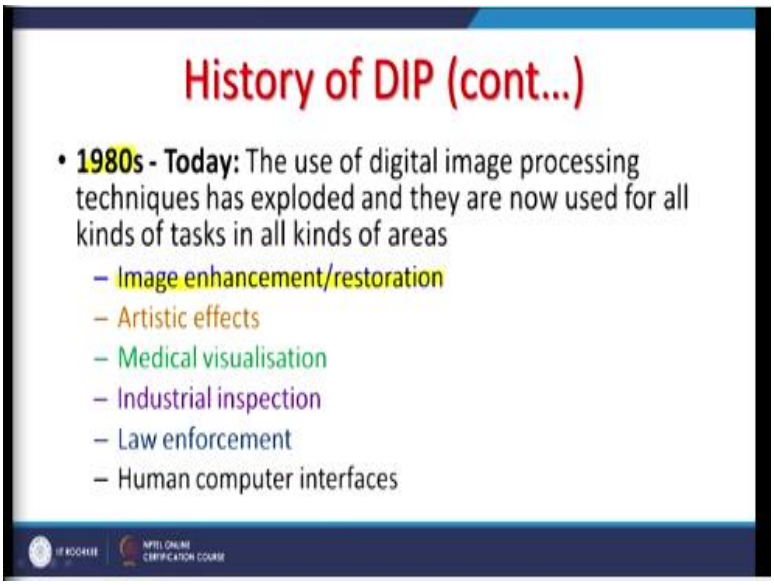

In 1980s the use of digital image processing techniques has exploded and they are now used for all kinds of task in all kinds of areas. And the development which has taken place in 80s many things of course has improved. And what are those areas where things have improved or are being improved, image enhancement, restoration of images, artistic effects.

And of course medical visualization in the field of medicine this image processing techniques have definitely also improved. And industrial inspections again there are a lot of applications of digital image processing. Law enforcement, human computer interfaces, and of course a in our remote sensing. So that image enhancement of satellite images is definitely there.

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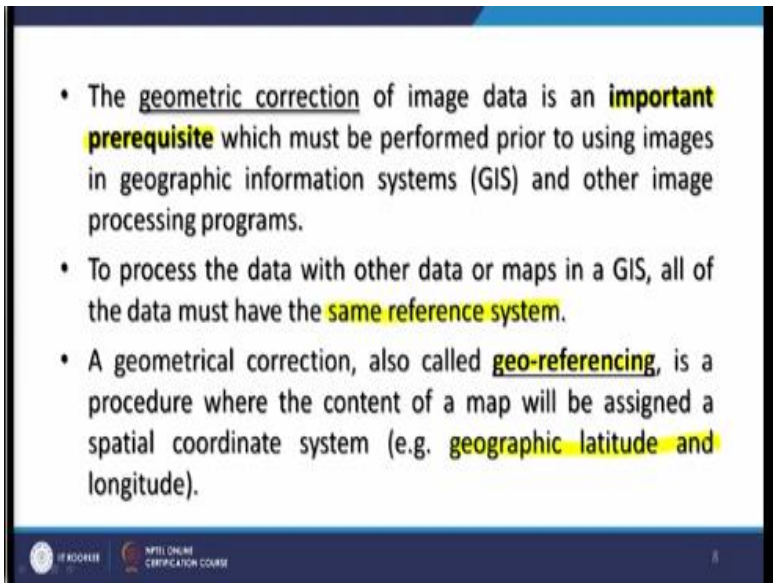

Now, one important thing also associated with satellite images is the you know their geometric quality. And ultimately if we want to use these images on a GIS platform, then we need to bring the geographic coordinates. And that is done through a processing which is called geo referencing or we also called geometric corrections. So, geometric correction of an image very important and which is prerequisite also which should be performed before we start using those images with other datasets which are in geography domain.

And like on a GIS platform or other image processing software, especially when we want to see various images or maps or images together in a multi layered system. Then we need that all these maps and images should belong to a same geographic coordinate system and therefore the geometric corrections are very much required. When satellite images are required, they are not georeferenced they do not have geographic coordinates, they are having only geometric coordinates.

And those coordinates are starting from top left therefore they cannot be used directly on a GIS platform or along with other datasets which will be in the geographic coordinates. So, this step is very much important and that is why important prerequisite is given this state has been given and this status. The process the data that other data or maps in a GIS platform and that data or the satellite images must have the same reference system as I have already mentioned.

That I can make a stack or multi layer system having maps and satellite images and different satellite images of different resolutions maybe have different dates. Then they should belong to the same reference system, then only it is possible to do it. And that can be achieved if all the maps and images are geo reference to the same different system. So, in geo referencing or geometrical correction which is also called a geo-referencing is produced where the content of a map will be assigned a spatial coordinate system.

And for example, the geographic latitude and longitude instead of geometric domain. Now, prior to image analysis the real serious image analysis starts some initial processing.

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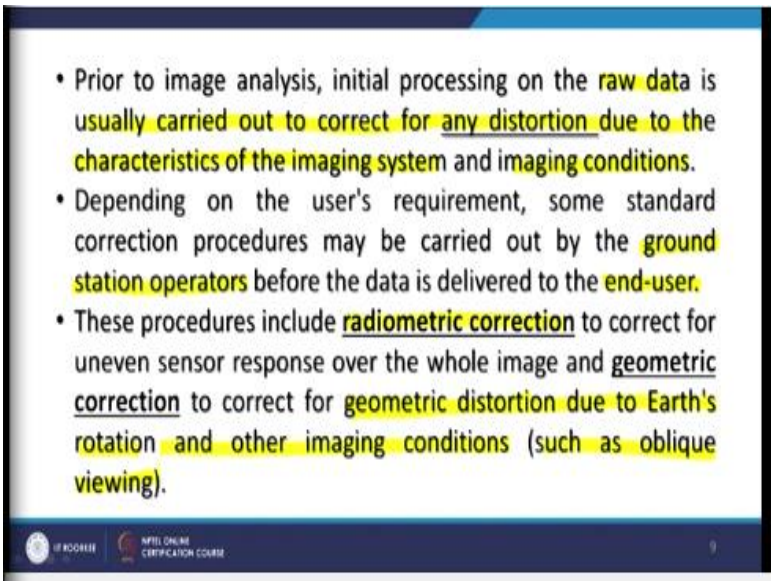

Or raw level processing or first level of processing level 1 be processing is done on the raw data. And which is usually carried out to correct any distortions due to characteristics of an imaging system and imaging conditions. Generally when we get the satellite images maybe from IRS or Landsat. So, if I go for IRS data then ISRO or NRSA or NRSC national remote sensing data centre.

They will be knowing about the characteristics of imaging system and imaging conditions. So, many times a first level of a correction or processing is done by them and then over the raw data. And then if we order the data or download the data, we get the data after first level of processing. And as I have mentioned first level of processing includes the distortions which might have been caused by the imaging system.

So, details are there, there might be some issues related with calibrations of different CCTs also. So, if that information is with them they also called as radiometric corrections. So if that information is with the agency, they will first perform that correction and then will be uploaded on the server or supplied to the user. So the raw data generally is but the data which is coming like in our earth station from NOAA AVHRR the first level and level one be processing is done in our end with our system.

And also we can using the orbital parameters orbit of the satellite, we can do a course level of geo-referencing. So, we can also assign using these orbital parameters, some geographic coordinates to the corners of the image. So at least not very fine geo-referencing but course level first level of geo-referencing is possible also using orbital parameters.

So obviously it depends on the user's requirements some people prefer the standard correction procedures and or some agencies may be carried out by the ground stations as I have already said before the data is delivered to the end user. So you know sometimes radiometric corrections are performed by the agency. Sometimes you can ask no, no I will perform by myself, but generally radiometric corrections world over are performed by the agencies themselves who acquire data from different satellites.

So, these procedures includes regimented correction to correct for uneven sensor response, as I have said the calibration issues over the whole image. And geometric corrections are also done to correct geometric distortions due to earth rotation in other imaging conditions. So this geometric correction is done based on the orbital parameters or might be when swath is very wide then the earth curvature plays a very important role.

And therefore on the edges we get this affect of oblique viewing and that may also be corrected by the agency who supply the data.

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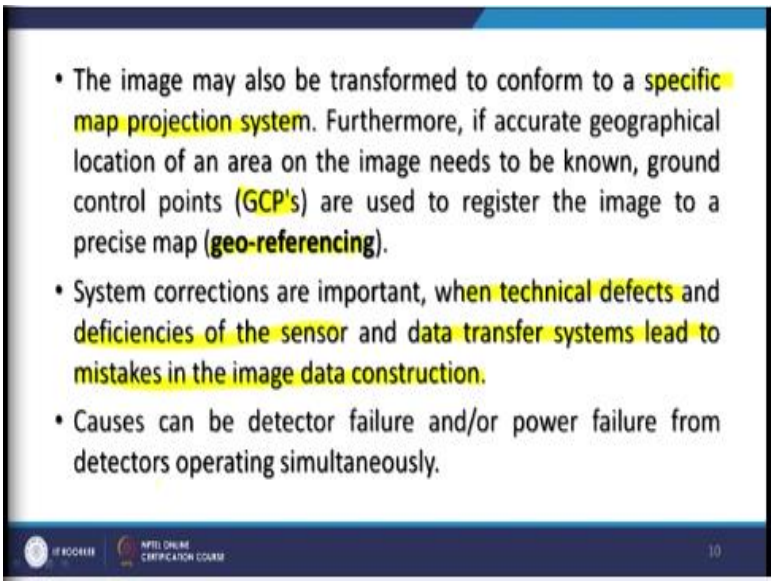

Now the images may be transformed to confirm to a specific projection system. We can like in this NDC of NRSA data centre if we ask them to do the geo-referencing. And produce a satellite image map in a particular projection and corresponding to a survey of India to proceed. Then that level of processing can also be done. So, they can also perform this thing and can transform the image to a particular or a specific map projection system also.

And also accurate geographical locations of an area of the image needs to be known, then these GCP's are used to register the image. So, how it is done in India that NDC is having their own library of ground control points which they have collected using differential GPS. I understand there are about 30,000 GCP's or for all over India they are having.

So, using those GCP's which has become a standard for them, they do the geo-referencing part as well. And then finally products can be generated even for having different safe top sheets of 50,000 scale or 25,000 the scale. So that kind of level of processing can be done that kind of geo-referencing can also be done. System corrections are important if there are systematic errors, those can be corrected quite easy.

If they are non systematic errors again these can be attempted to remove to some extent. So, there may be technical defects, there may be deficiencies of the sensor. And this information is generally with the agencies and the data transfer systems leads to mistakes in the image data

construction. So if all these details are available then some level of corrections can be performed on the raw images which are acquired by a satellite earth station. And these detectors related or sensor related failures or issues or power failure from detectors can also be resolved.

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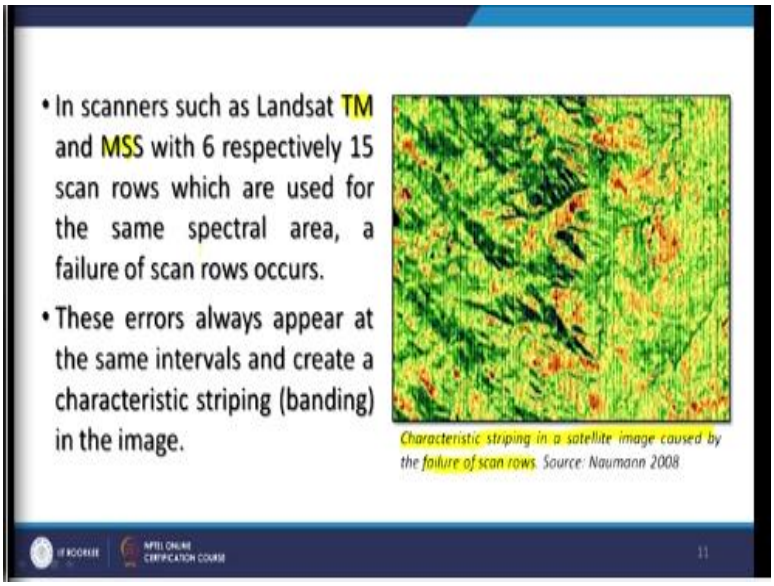

Here I take an example of Landsat images where we are we are seeing these stripes there. If you see carefully there vertical lines idea and obviously this is because of the this because of the scan failure of a scan rows. And also different responses by CCDs giving that one. So, this like in Landsat TM or MSS, there were 6 respectively 15 scan goes which are used for the same spectral area, failure of scan row occurs.

And then definitely image becomes less usable, for certain studies still one can use such images which are suffering from such kind of distortions. And if in certain applications obviously these images cannot be used because they will give you errors in the outputs. These errors always appear at the same interval if there are systematic errors because of sensor related thing. And can create a characteristic of banding which we are seeing here in the image.

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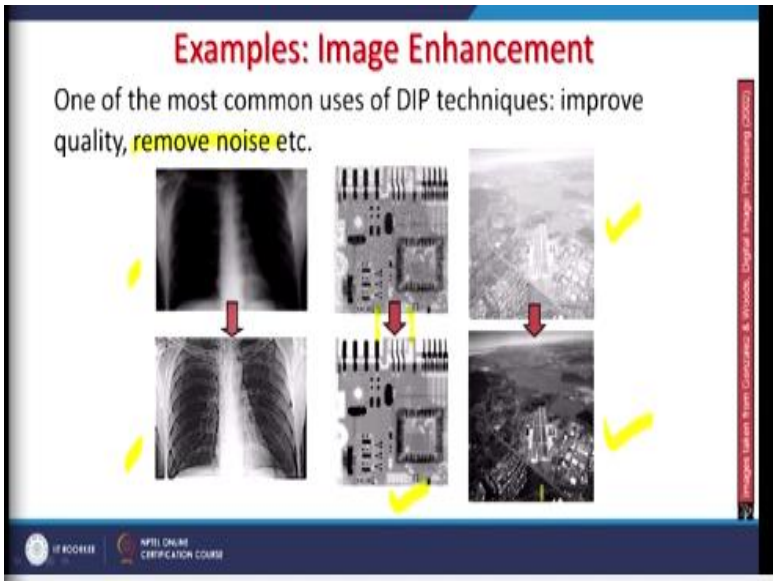

And as I told you that systematic errors can be corrected because one can develop a program. And we know that at what line, what row is missing or there is a problem with the sensor or calibration, so those things can be corrected. But none systematic errors are difficult more challenging to correct. Now there are enhancement, simple enhancement techniques which of other domain also like you know in medicine or medical sciences people use.

This is one the top one is this X-ray and what we are seeing if we do the enhancement simple enhancement like contrast enhancement and other thing. We start seeing much more details on that X-ray compared to what original. So one of the most common uses of digital image processing techniques to improve quality and remove noise etc. if it is there.

And that way we can definitely make images more interpretable and these images can be used more reliably either by doctors or some other civil engineers or maybe and decision makers. So, one example of simple X-ray has been enhanced by image enhancement techniques digital image enhancement technique. That here in the middle, the top middle it is suffering from some noise as you can see there are speckles are there in between in this images, some black spots are there.

So, these speckles can also be removed or minimized and this is what you see this result here which is much more interpretable, much more easier to understand than image with the speckle.

So noise removed, noise can also be removed through digital image processing techniques. Another one when see this is a oblique aerial photograph might have taken by at aircraft.

And when you are flying very close to the earth this atmospheric conditions plays very important role. And this photograph the top one top right is showing some hazy characteristics in the image are in this photograph. But implying a digital image simple digital image processing techniques which we will be seeing later, then this can be improved. And see the interpretability has definitely increase significant data is increased as be compared with the raw image.

It was showing too much a hazy kind of thing now, because of enhancement techniques now things are much more clearer interpretable and correct decisions can be made based on these images.

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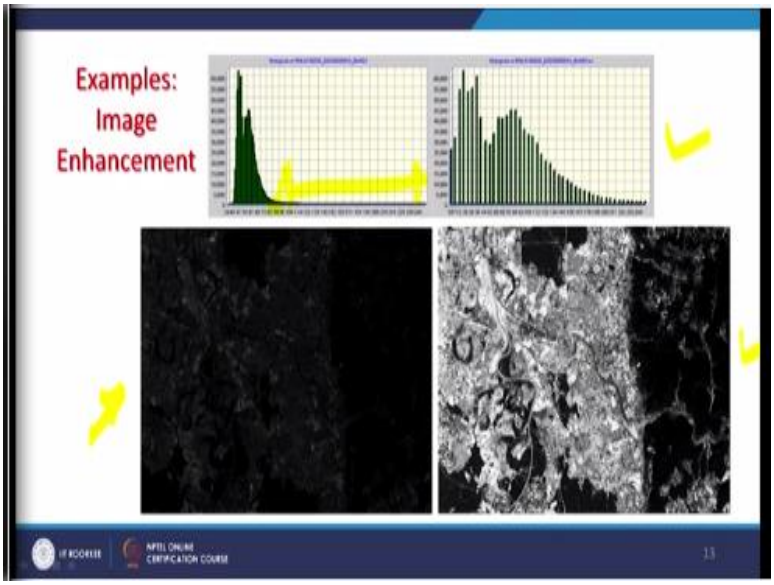

Now, one more example of real satellite images, when we see the raw images generally we see like this which we are seeing here completely almost blank. You are unable to see anything here, why because when we see the corresponding histogram of this image, the raw image most of the pixel values are very close to 0 or between up to 100 maximum. And this is an example of 8 bit image and we expected that the distribution of pixel values should be with 0 to 255.

So, this much area of the range which is available of radiometric resolution is not being used by this image. And therefore the histogram which is the frequency of occurrence of pixel values is just restricted in the beginning of just maximum pixel value is 100. But a if we imply the image enhancement technique very simple like contrast enhancement, what we can do we can redistribute.

The pixel values of this histogram to occupy the full range that is between 0 to 255 like here on the top right histogram. And once we do it force the image to distribute pixel values like this, then see the quality of the image has improved. The image which was not usable at all in the beginning the left image now, right image is simple enhancement is done and now many things are very clear here.

So, this is what this kind of If I call a magic, this is what kind of magic is done. But the best technique best way to approach this thing is whenever you get a raw image whenever you download a satellite image. First go and construct a histogram, these are creating histogram of any image input image is very easy in all these standard softwares they about the softwares we would be discussing in the next lecture.

So, once you are having histogram, you know the what is now range of distribution of pixel values. And immediately then you can you know basically pull these values in the full dynamic range and that dynamic range is between 0 to 255. And once you did redistribute these pixel values then you get these results which are very good. But still there are parts which are still in dark might be shadow, might be some other reason.

So, therefore, we have one has to look because you are having a long tail of though high pixel values but number of those pixel values are less. And of course dark values are they are much more that is why these peaks are still there. So, we can further enhance later on maybe rather than a simple linear enhancement, we can do nonlinear enhancement more sophisticated enhancement can also be performed to improve the image quality which we will be seeing little later .

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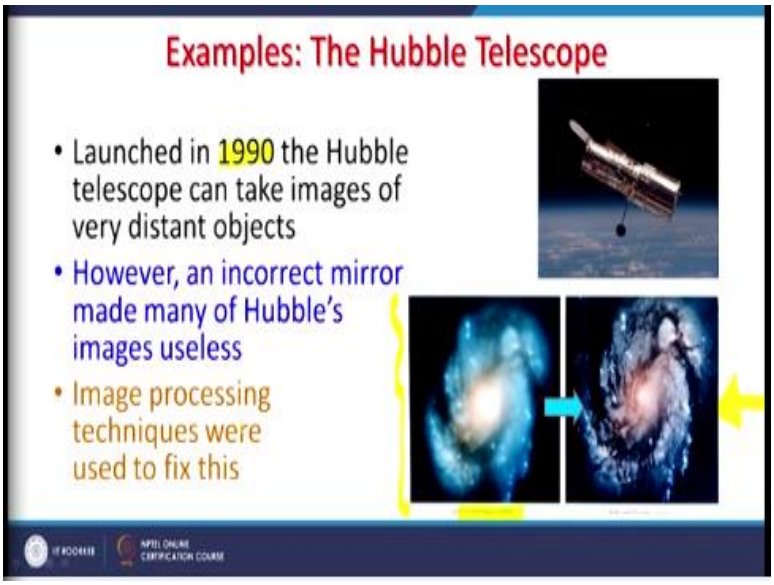

Now if you remember this Hubble telescope episode, there were some problem about the focus of this Hubble telescope which was launch in 90s, which was taking the images of different you know, these planets or part of galaxies. And see what kind of quality the image is had taken by these Hubble telescope. But implying digital image processing techniques enhancement techniques, the image, the bottom right image what you see is the improved image after enhancement, image processing.

So, such because it is not possible to correct that focusing problem and it was not possible again to launch another telescope like say Hubble telescope. So, whatever was coming through these telescope these images were then subjected to image enhancement and quality and interpretability usage of these image was improved significantly.

So, this is how incorrect a mirror made the Hubble images useless or out of focus and image processing techniques were used to fix this. So in our day to day life also, lot of images which are important now it cannot be taken away but still these can be improved implying digital image processing techniques.

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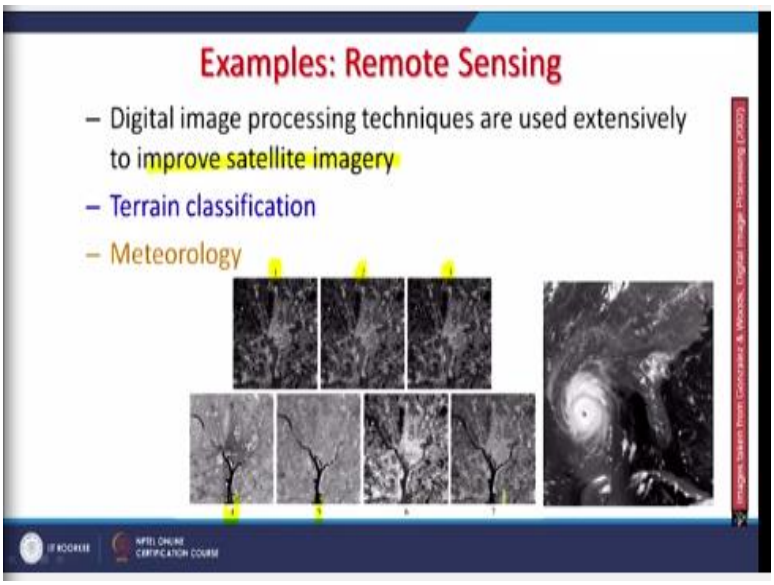

There are a few more examples directly from remote sensing domain, that remote sensing techniques are used extensively to improve the satellite image quality and interpretability. These are used for terrain classifications and these are also used in meteorology and other things are there. Like there are examples of you know this 7 band example is shown here of Landsat TM that you are seeing band 1 to band 4, 5.

So, different bands are giving images of different part of EM spectrum. Now, the best technique is if you are working in multispectral or going for a false colour composites which we have already discuss in previous lectures. Then individual band should be first enhanced and then combinations would be made. That will really provide you a very significant quality change in the satellite images.

So, that is another you know help to improve the images, night lights of the world dataset that is to some extent it is also very useful for different parts of the world. Even for India these images can be acquired, but when they are taken in night time the original quality or quality of raw images very poor. But when there these images are subjected to image enhancement you get a very good quality, what do you can use with nighttime images.

The global inventory of human settlement not hard to imagine the kind of analyze there might be done using this data. During the Diwali or after Diwali or some blackouts maybe failure of the

grid, electricity grid, these things can be assessed that which part were affected. And during the Diwali celebrations, how much lighting was there in the country, there are many other applications of night time, that is a different issue altogether.

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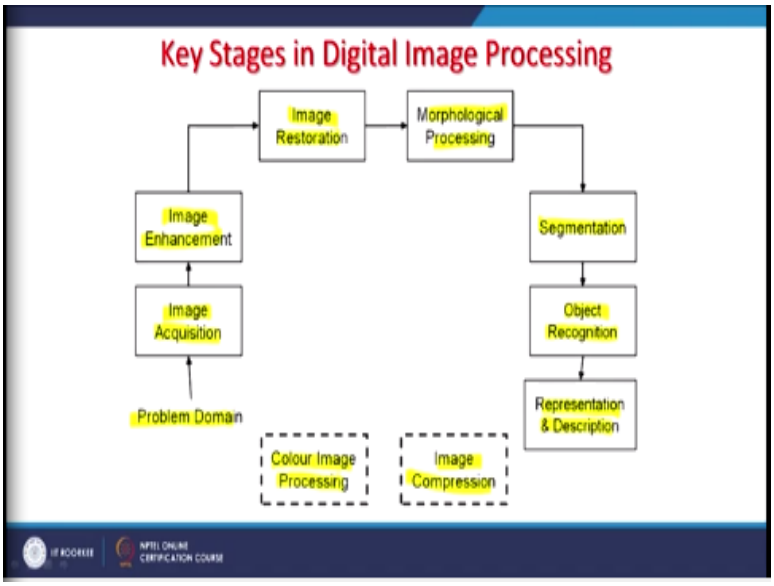

Now, what are the different stages of digital image processing that we will go. So first is this problem domain and then image acquisition. Once the image has been acquired, maybe first level of processing image enhancement is done, image restoration is done, morphological processing is done. There might be segmentation of images that is sometimes also required, then maybe at higher stages of digital image processing, object recognition which is at the stage of classification of images for certain purposes.

So, computers are trained to identify different objects recognize them and categorize them in different categories and then finally representation and description. Also in between, sometimes image compression is also required, that to be done to reduce the size of the image and improve on the redundancy of the data. And also we go for colour image processing for multispectral images.

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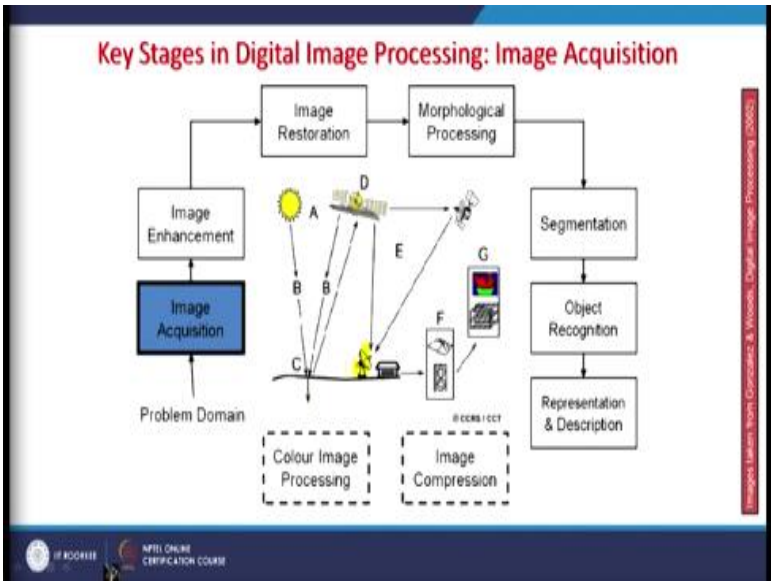

So, this kind of thing is done, of course we will go one by one image acquisition that is from coming data from coming to the satellite earth stations.

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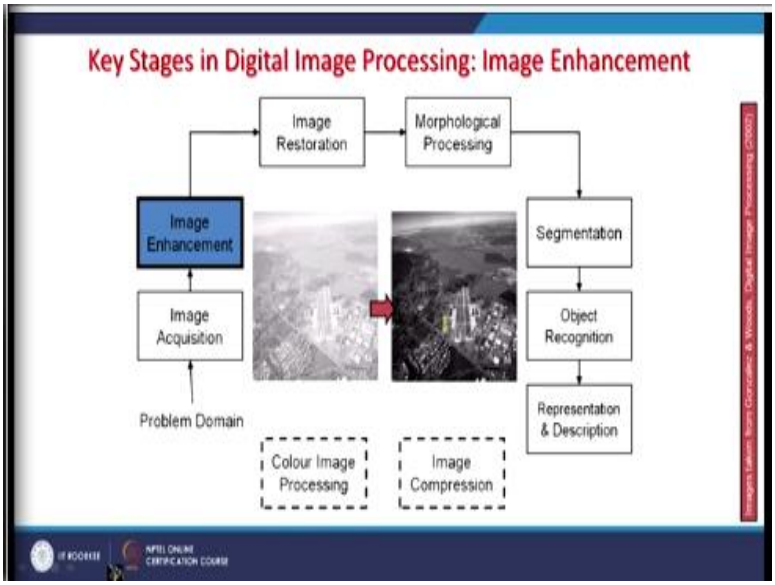

Then image enhancement in image has come that can be enhanced like example here.

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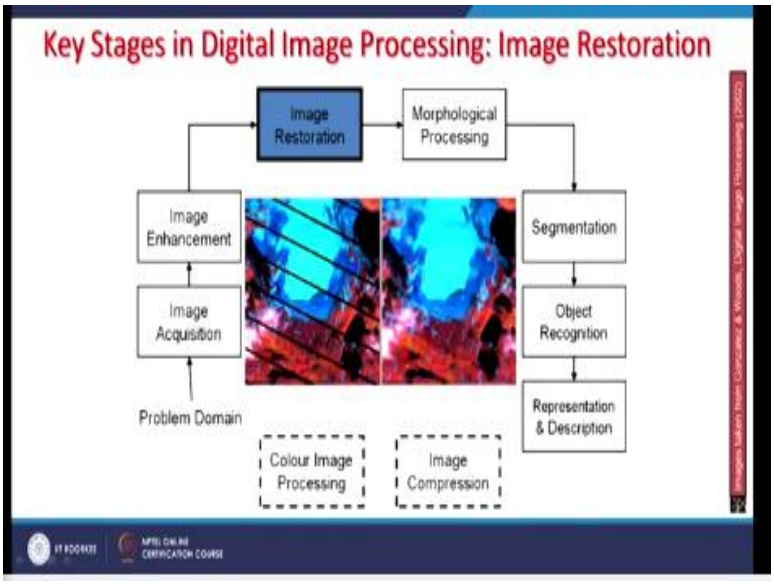

Then image **re** restoration as mentioned that there might be some errors in the sensor itself and you might see these stripes within the image. But since these are systematic errors, and therefore, it is easy to remove these errors and this is what it has been demonstrated here. That systematic errors have been removed through a programming through a particular software and then you get a better quality image.

Of course this is having some issues that sometimes even these stripes are not completely removed as you can also see. But to large extent the image quality improves significantly.

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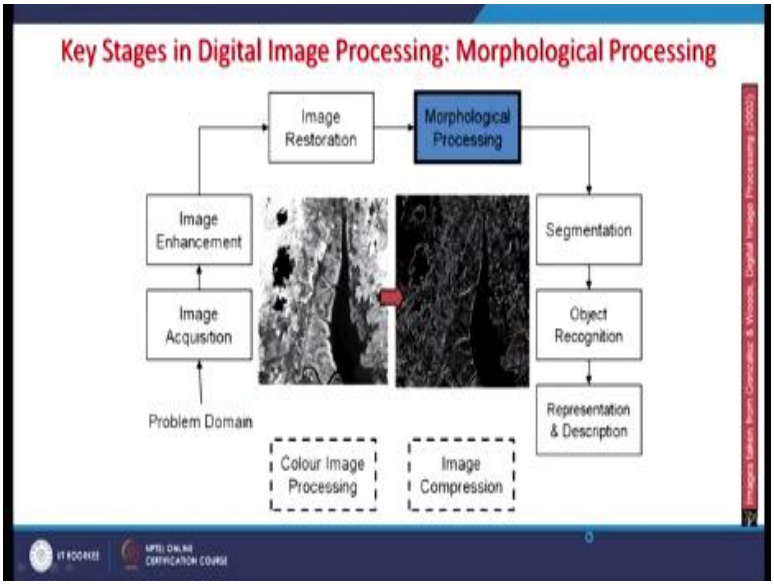

The next is the morphological processing like here I want morphological processing means spatial filtering which is done to enhance certain features or reduce the frequency of certain features. So for which morphological processing can be done, so this is on the left side is the input image and on the right side after morphological edge enhancement. So, edges of all objects which are present on the left side of image have been enhanced and it becomes almost a binary image.

So, you are seeing the boundaries of all those features which are present on the left side image, different times in different kinds. Sometimes you want to enhance edges, sometimes you want to make a image more smoothing rather than having sharpness in the image, that is also done under this morphological processing. Then segmentation is that basically moving towards the classification of the image.

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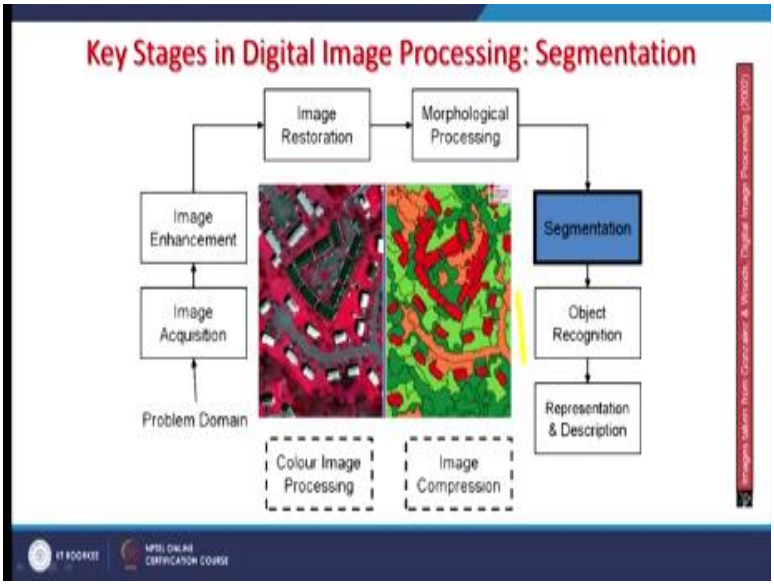

So this is a very high resolution, false colour composite on the left side and then you are going for classification, different buildings have been identified as one category as you can see here. And green areas have been identify another category, open areas have been identified another. So, this segmentation the image has been segmented into 4 classes and then these becomes much usable and for decision makers.

Because many decision makers may not be good on interpretating the image, satellite images where here it is possible. For them easy and incorporate these output on the what is being displayed on the right side along with other datasets.

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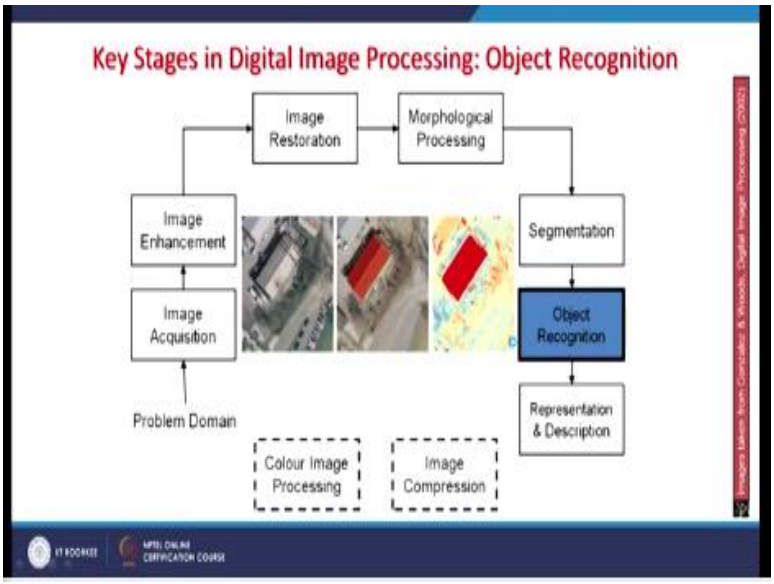

Object recognition is also done at the very advanced level of classification in digital image processing, this raw image first level of processing. And then finally, object has been identified here that this is a some storage house or something.

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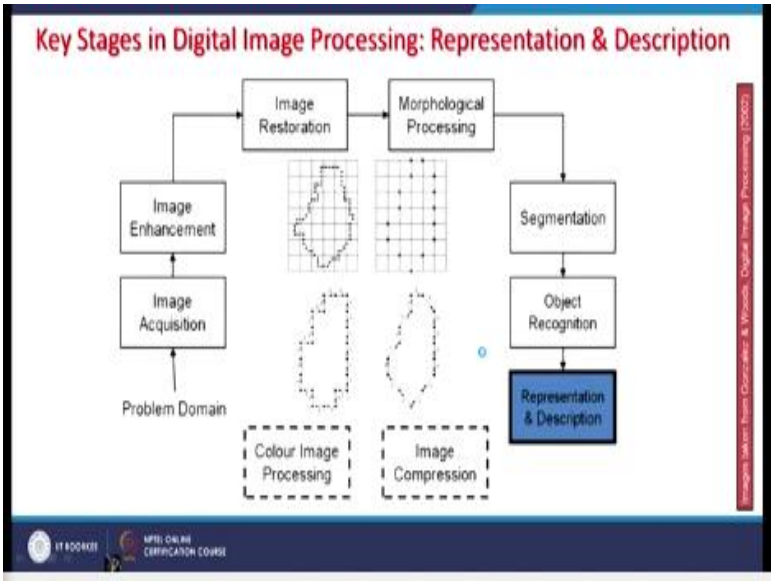

Now, representation and description that is also a part of almost last part of digital image processing. And that is as you can see here that you can represent the boundaries in a different

manner as in this example it is shown. So, the first one is this is the input image, where you are seeing a certain feature, you get these corner values and then you start representing. And finally, you end up with a simple boundary of that object which was present in the raw data or input image.

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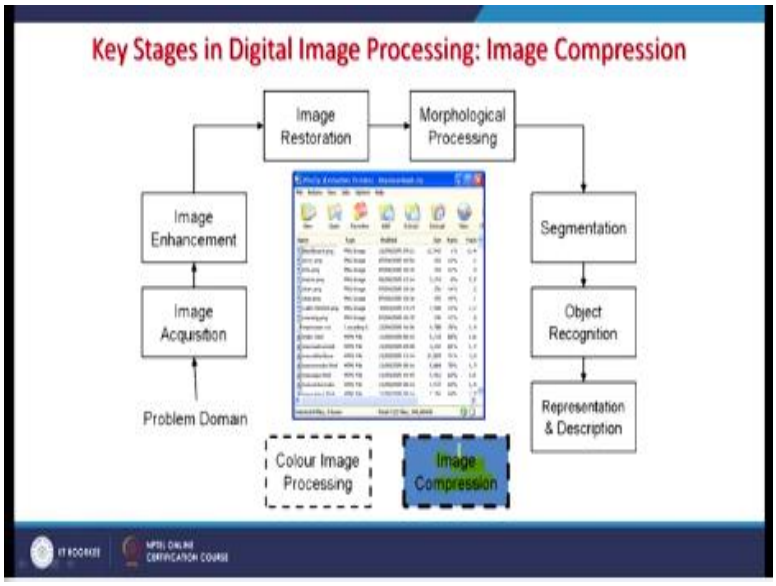

Image compression as I have already told you because when you go for aerial projects you have to handle a lot of data especially the satellite images occupy a lot of space. And especially your multispectral or hyperspectral images will occupy lot of hard disk space, your processing may go slow. And therefore many times we have to go to resort to the data image compression.

There are different compression techniques are available, all compression techniques are not supported by all image formats. So, one has to also learn this part of image processing, that is image compression, that is very much also required many times.

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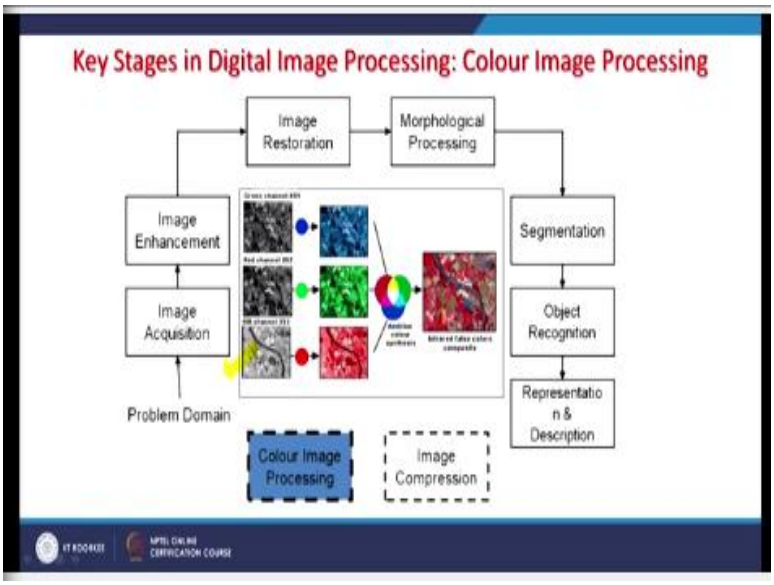

And then of course, colour processing, this false colour composite construction of false colour composite, the concept of false colour composite. We have already discussed but very briefly, 3 channels the bottom one on the left bottom is the infrared channel which is assigned red colour. The remaining channels are assigned blue and green colour when you go through additive colour scheme, combined these 3 bands of 3 different colours RGB, you end up with a standard false colour composite.

So, this is how the colour processing is also done. So, this brings to the end of this discussion about and the importance of digital image processing. In the next lecture, we are going to discuss what are the different options available through softwares, digital image processing softwares. To perform all these tasks and improve our images, so that better interpretations, better analysis and better uses can be achieved with this, thank you very much.