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**Digital Image Processing of
Remote Sensing Data**

**Lecture – 07
Image Histograms and Statistics**

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Hello everyone and welcome to 7th lecture of this digital image processing of remote sensing data course and this particular lecture we will discussing image histograms and statistics and this understanding of histograms of the image and associated statistics is very important when we go for image enhancement and techniques which are many we will discussing in later lectures.

So first basically what is histograms an histograms is a an graphical representation of a statistics and which give you visual impression of distinguished of the data how data is distinguished of your image is distinguished in a graphical form. So you are having bars and one X you are having frequencies and on the X axis you are having the values which are groups and therefore you see the bars very soon.

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What is a Histogram?

- In Statistics, **Histogram** is a graphical representation brings a visual impression of the distribution of data.
- The Histogram provides a univariate (one-variable) description of data.

I am going to show some examples of histograms and associated images so histogram provides a basically univariate one variable description of data and generally when we want to understand the statistics of an image then individual bands histograms is important to understand the variations which are presenting the data.

A variations of the pixels value which are presented in the thing so image histogram is a type of histogram that X has a graphical representation of the lightness or colored distribution or colored in case which we are using colored image then three bands histograms their you can also see the individual histograms or different bands or combined one as well.

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Why Histogram?

- Histograms are the basis for numerous spatial domain processing techniques
- Histogram manipulation can be used effectively for image enhancement
- Histograms can be used to provide useful image statistics
- Information derived from histograms are quite useful in other image processing applications, such as image compression and segmentation.

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And the colored distribution and digital image and it plots the number of pixels in each value and in histogram or the basics of various spatial domain processing techniques and which are an image enhancement techniques which we will see relatively later so histogram manipulation can be used effectively for image enhancement and histograms can be used to provide useful image statistics.

And this information derived from histogram are quite useful in other image processing applications such as image compression and segmentation because image compression is also part of the digital image processing which we will discussing in some later lectures and because of large data sets which is handled in the remote sensing and digital image processing.

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And therefore the image compression techniques are also employed to reduce the data or segment the data so the program basically is mentioned that the historic this is the frequency distribution in a bar graph and this is a bar graph which I was mentioning that here you are having the data of the pixels values on the Y axis you are basically having and the frequency.

And this is a distribution of pixels are against the frequency so how many times the range of pixels values the range widing because for each pixels values we do not having a line or group of pixel values a bar is here or building is here so for group of pixel values what is the repeating of these pixels values within that image or within that band.
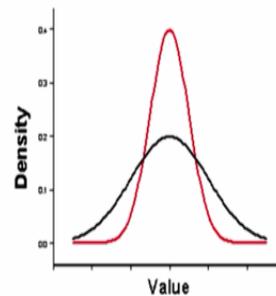
So this is how it is distributed so if frequency distribution is a display how often observed values fall within certain intervals or classes and one can specify the number of classes that mean how many bars you want to have how many in groups you want to have what should be the width of these groups.

So that one can also be decided and relative proportion of data that falls in each classes represented by height and that is the frequency so this gives us the some information in a graphical form which is easy to understand so brings basically histogram about how the pixel values are spread or represent within the image or a band.
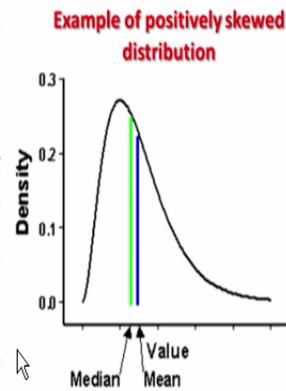
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The spread of points or pixels around the mean values is another statistics of displayed histogram frequencies distribution like here we say normal distribution when sometime you may be having not very high pixels values within a image so you may get in an distribution something like this or you may be having a very high pixels values within a same image then you may be having an distribution but this is a very normal kind of distribution or the spatial distribution is there.

But generally in images you may not get this kind of distribution so the varying in standard deviations for the black frequency distribution as soon here are greater than those for red frequency distribution. So just looking histogram lot of statistics can be assist about the image and what image processing or enhancement technique are to employed will be based on that decision will this going to be based on the how histogram look for an image.

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So like in this one I am having one example here that this is the positively skewed distribution so that used the lower values are having high frequency and this is not a normal distribution but it positively skewed and distribution which we are seeing and this mean values and median values very close by so the histogram are frequency distribution is also characterized by its shape.
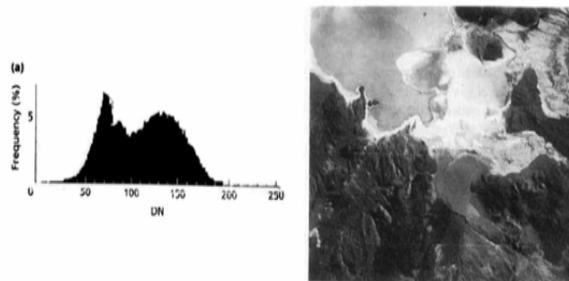
The coefficient of skeweness is a measure of the symmetry of the distribution and for symmetric distribution the coefficient of skeweness is zero so if is a that means if coefficient distribution then the skeweness will not be there and therefore their coefficient skeweness will also be zero. If distribution as a long right tail of large values like in this example then it is positively skewed and if it is a long left tail of small values then it is negatively skewed.

So while looking just shape of histogram lot of information can be derived and the mean is larger than the median like here it is if this is a mean is larger than the median for positively skewed distribution and vice versa for negatively skewed distribution so right histogram this one so it is positively skewed distribution which we are seeing here.

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And this is the image is also shown here and corresponding histogram so you can see that if there is a this light of this area are there may be water bodies bits having higher values and therefore you are seeing one peak which is corresponding thing to this brighter areas. And then you are having also darker areas so darker areas are represented here and the brighter areas are represented later on here so the two major loops which are representing pixel values which are represent in the image.

So for simple interpretation you can say that they are areas a large number of areas which are having darker pixel values which are represented in the first part of the histogram and then lighter values or lighter pixel values having high pixel values these are represented in a second and this log of histograms of an imaged represents the relative frequency of occurrence of various gray levels in the image.

A grey levels sometimes you also called them digital number pixels values and so on grey levels band we are having single band and presenting as a grey scales so we called a grey levels. So an image in a single band of digital remote sensing data is representation of how the radiant energy is reflected or emitted by the surface distributed in two spatial dimensions.
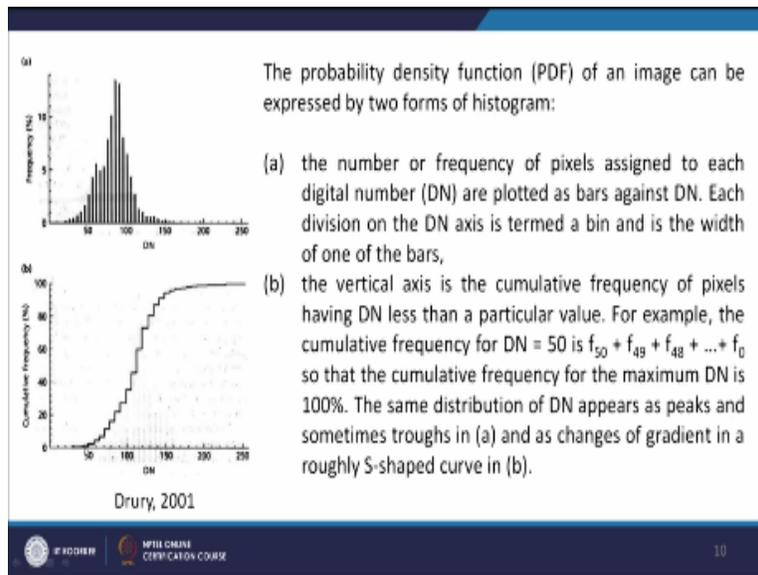(Refer Slide Time: 09:21)

And the energy is expressed as DN or digital number pixel values and which is a displayed or represented by variations in a brightness showing as different grey levels and since the eye is capable of distinguishing only about 30 grey levels in a black and white there is a human eye is not at sensitive that we can distinguish more than 30 grey levels.

Whereas in colors we might be having more capability but when we are having single band image though in a image processing techniques we are normally go for eight bit image that means total 250 variations' and we can have in an image. So an image can be expressed also in statistically probability of finding digital number of given value within it.

And this major is properly termed the probability distribution function or in sort we called as PDF so PDF is represented most conveniently why histogram numbers of pixels which are present which regardless of spatial position and within a image and having particularly so whatever there is a distribution wherever they are located in histogram it takes a immaterial only for fixed values and in the number of times the same pixel values have appeared that will go as a frequency.

So this probability distribution function which you can see here that this is a histogram an frequency on the Y axis and digital numbers as in simple as a histogram so here are plotted and this curves will bring you there is a PDF so number of frequencies of pixels is assigned to each digital number DN are plotted as bars against DN.

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The probability density function (PDF) of an image can be expressed by two forms of histogram:

(a) the number or frequency of pixels assigned to each digital number (DN) are plotted as bars against DN. Each division on the DN axis is termed a bin and is the width of one of the bars,

(b) the vertical axis is the cumulative frequency of pixels having DN less than a particular value. For example, the cumulative frequency for DN = 50 is $f_{50} + f_{49} + f_{48} + ... + f_0$ so that the cumulative frequency for the maximum DN is 100%. The same distribution of DN appears as peaks and sometimes troughs in (a) and as changes of gradient in a roughly S-shaped curve in (b).

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In case of histogram is division on DN axis is termed as a bin and is the width is the one bar and the in vertical axis of cumulative frequency here the y axis of pixels having DN less than a particular value for example the cumulative frequency of DN = 50 that is f 50 + f49 48 so on till 0 f0 so that the cumulative frequency of a maximum DN is 100%.

Mad the same distinguish of DN appears as peaks and sometimes troughs in a and as a in case o histogram and the is gradient in a roughly S shaped curves her what we are seeing here.

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- The histogram of DN frequencies is probably the single most useful measure in digital image processing.

- Its shape indicates the contrast and homogeneity of the scene.

- For instance, a scene of a homogeneous surface with a low contrast will produce a histogram with a single, sharp peak.

- A broad single peak suggests homogeneity but a wide range of contrast.

So histogram of DN frequency is probably the since the most useful measure in digital image processing and this shape indicate the contrast and homogeneity of the scene. So for instance a scene of homogeneous surface with a low contrast will produce a histogram with a single or sharp peak so if an image generally when images are acquired by satellite sensors they do not have much contrast and so if you look the histogram of a raw image you may not find a very good quantity of image for interpretation.

And because if you see the histogram will be values or these bars of histogram would be on the lower side in the and the values will be might having very low value and if a the image belongs to a like a dense forest area almost all areas with that image are forest then all will produce a large single peak or may be a large water body is present then you will have a very sharp single peak within the histogram of that particular image.

So basically histogram is a represent technical representation of pixel values of an image so accordingly whatever the features which are present they will be reflected in the histogram but in generally raw image will have histograms in the if you think in terms of x axis the in the initial values there the histogram will be located so brought single peak if you are having a single sharp peak then the your having homogenous surface with the low contrast scenario and when you are having a brought single peak which I suggest again homogeny what wide range of contrast.

So interpreting histogram will let you know will allow you to understand that which enhancement like linear contrast or nonlinear contrast or histogram which enhancement technique one as to imply to improve the quantity of image for image interpretation.
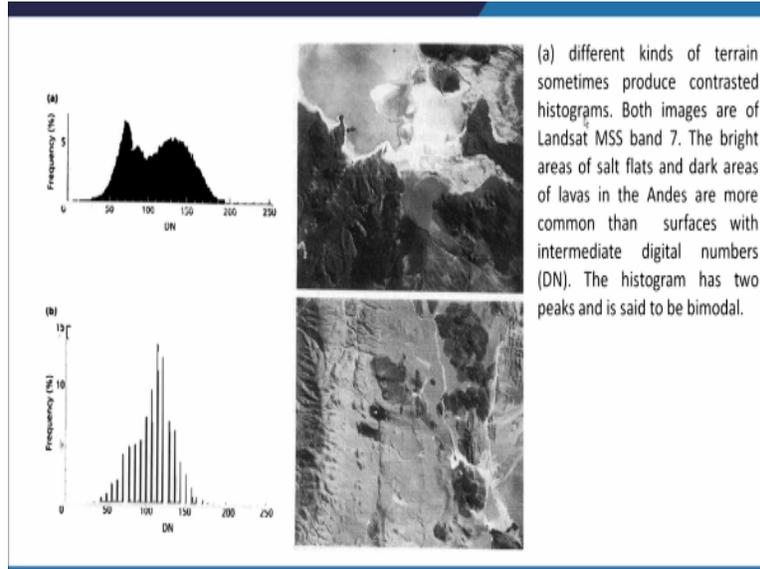
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So image that contains several distinguish types of surface or may so multiple peaks so if you are having an image which is having larger water bodies also having a snow areas may be sand bodies may be forest may be agricultural land may be built land within one image it is possible then you will have multiple peaks in within the histogram of that image and each of a has these peaks will have significant with different average brightness and we with clear separation between these peaks.

So that means if a the pixel values are occupying the entire range that means there occupying the entire x axis that means there is a good features are there and less enhancement may be required but this is very rare it happens because generally it has been found that in raw image the your bars will be on the initial or lower side of pixel values as there average brightness becomes more alike.

So the peaks will began to merger if the features are having same kind of characteristics mean same kind of pixel value then you do not see these distinguish peaks and other sides tributes of histogram gave a kind of statistical sort hand of an image the presence of tails and the degree of asymmetry which we have disused of the peak both indicate important structural features and image that will be really obvious with form other pictures for itself, so there are two examples one this image.

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(a) different kinds of terrain sometimes produce contrasted histograms. Both images are of Landsat MSS band 7. The bright areas of salt flats and dark areas of lavas in the Andes are more common than surfaces with intermediate digital numbers (DN). The histogram has two peaks and is said to be bimodal.
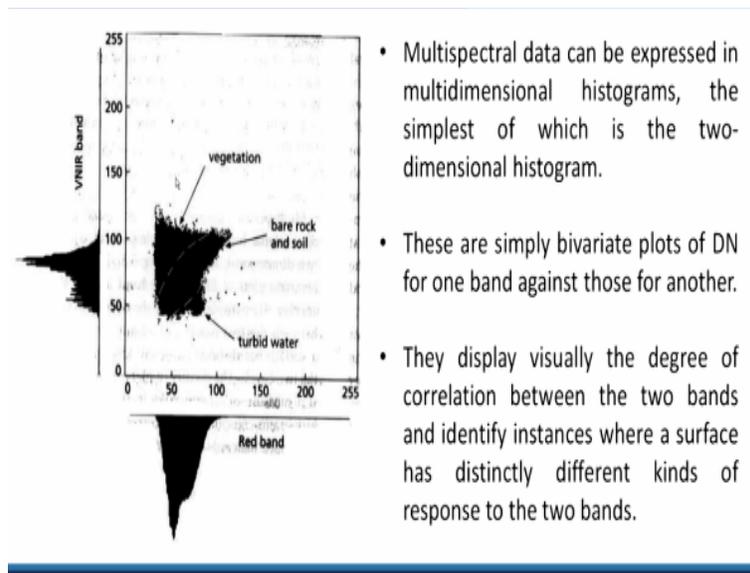
We have already seen corresponding histogram now another Image is taking here and here you have after bodies and some darker rocky areas here you do not have water bodies with some forest and some other light colored rocks are there light tone rocks are there so different kinds of Terrance sometimes produce contrasted histograms here you are having two picks here you are having single once are peaks here for this image because you do not have two types of distinct features.

As see in first one and then this image of a belongs to ND's mountains as a simple probably T density function here which gives nearly symmetrical uni-model histogram even though area with distinctly different DN values are visible, so a histogram can tell lot above in the an image and also it can indicate that what kind of image processing techniques would we require to be employed in this case.

So that is why it is important one that understand first before we go for an image enhancement techniques, now it is not only that you will be handling in digital image processing only one band or single band image we go for multiple because now people are not only talking multi spectral but high perspective remote sensing so there 100's of bands are there well initially from one band that is a single histogram a, we go for two dimensional histogram. And then this kind of distribution that will be through a scatter plot is possible.

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- Multispectral data can be expressed in multidimensional histograms, the simplest of which is the two-dimensional histogram.

- These are simply bivariate plots of DN for one band against those for another.

- They display visually the degree of correlation between the two bands and identify instances where a surface has distinctly different kinds of response to the two bands.

And they says that multi spectral data can be expressed in multi directional histograms as you can see or multi dimensionless histogram and the simplest of which is the two dimensional histogram or also we call as scatter plot so in a scatter plot instead of having bars like in a simple histogram for single band now we will points for each pixel values which is corresponding to another band so suppose here in this case you are having red band displayed in an access and very near infrared band is displayed in the Y-axis.
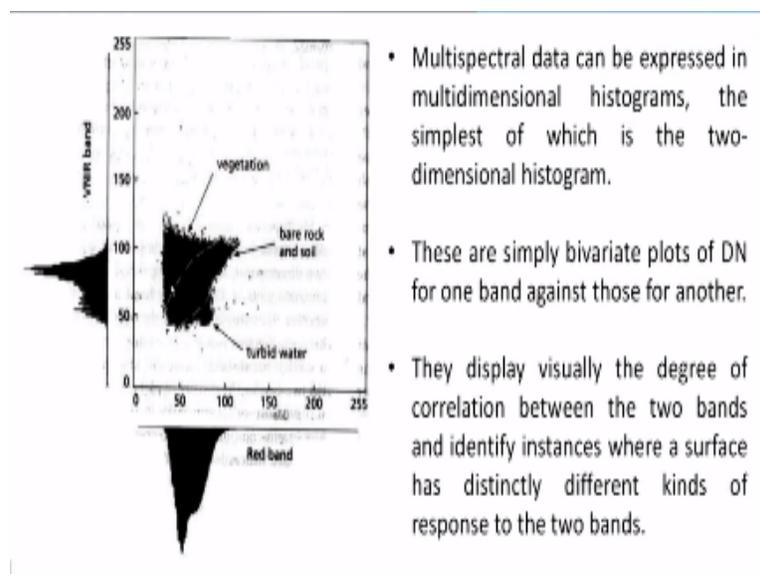
So now the values which is having say value here which is having a pixel value 100 and in red band having value say 50 would be plotted some area so instead of having bars in scatter plot you will have a just point which will link to our corresponding the pixel values in the both the bands which are present here but in graphical forms may be two dimensional maximum three dimensional such as histograms are possible but beyond that in graphical forms it is not possible but in from statistical point of view it is possible to involve as many as one can think or required to be seen in the statistics so these are simply basically also called as bi-variant plots of pixel values for band against those for another and they display visually the degree of correlation.

Between the two bands if you are getting a all pixel values are plotted along a line here which is starting roughly from 0 and that means they are having a very high correlation but if it is just a reverse case that they the most of the values are getting plotted and something like this and then you are having a completely different two different bands, we will belonging to two different parts of EM spectrum, so one has to see like when we interpret the for single band we interpret

the histogram similarly in case of by variable plot are scatter plot we have to make interpretation whether how they are correlated or not in.

There are some other application by bivarite plots in may be in the next lecture in which we will be discussing in how these can be exploited in the case of de-correlations stretch principle component analysis and others so these are also important to understand the distingusion and the correlation between different bands which are represent in multi spectrum image and also will allow you to choose later one which enhancement technique will be required so like in this one the vegetation is getting plotted here.

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- Multispectral data can be expressed in multidimensional histograms, the simplest of which is the two-dimensional histogram.

- These are simply bivariate plots of DN for one band against those for another.

- They display visually the degree of correlation between the two bands and identify instances where a surface has distinctly different kinds of response to the two bands.

There as the bear rocks and the soil are plotted here and the water which is having the high turbidity that distilled water that is plotting on this and the lower right side so this can give us lot of information about the image and also the bi-scatter plots also allows they are used a while classical image classification is perform so they are very important to understand.

So the density of the plots of the individual pixels is a major way that peaks in the one dimensional histogram coincides if you are having the density high density that means in two

bands they are having the almost same pixel value within the scatter plot highly correlated data or classes of surface materials.
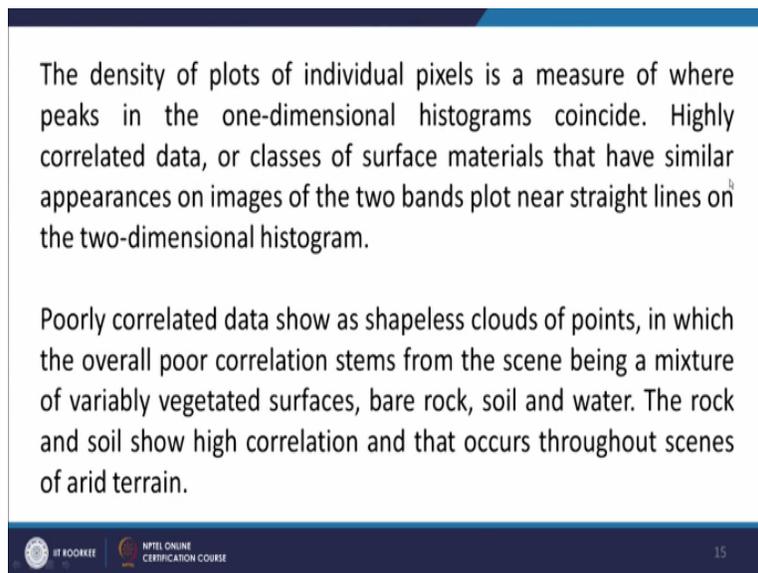
The density of plots of individual pixels is a measure of where peaks in the one-dimensional histograms coincide. Highly correlated data, or classes of surface materials that have similar appearances on images of the two bands plot near straight lines on the two-dimensional histogram.

Poorly correlated data show as shapeless clouds of points, in which the overall poor correlation stems from the scene being a mixture of variably vegetated surfaces, bare rock, soil and water. The rock and soil show high correlation and that occurs throughout scenes of arid terrain.

That have the similar appearance on a image of two bands plot in the straight line on the two dimensional histogram that means the both bands the pixel values are highly correlated and from the principle point and component analysis or even in the image classification or even for the false color composite generation then one band can be done in that case so we can drop by making certain and in sometimes when you are having like in case of line slide you are having six seven channels present with you do no which three channel which you will use to create a color composited.

So the best thing in first to do an such analysis and see the which bands are correlated so if the two bands are very high correlation that means they are having a 45°straight line that means they are highly correlated so either band cam be taken for the color composited where as the band which you will lose taken which are having very less correlation data poorly correlated data so

shapeless clouds of points as you have seen in this particular example and that you are having the shapeless clouds of points in which over all the poor correlation from seen being in the mixture of very low vegetative surface bare rock soils and the water so in all kinds of these such nature feature are present within one area and within one image of the different bands then you may get a shapeless a cloud well distillated with the with two dimensional so the rock and the soil high correlation and that occurs throughout the scenes of arid terrain.

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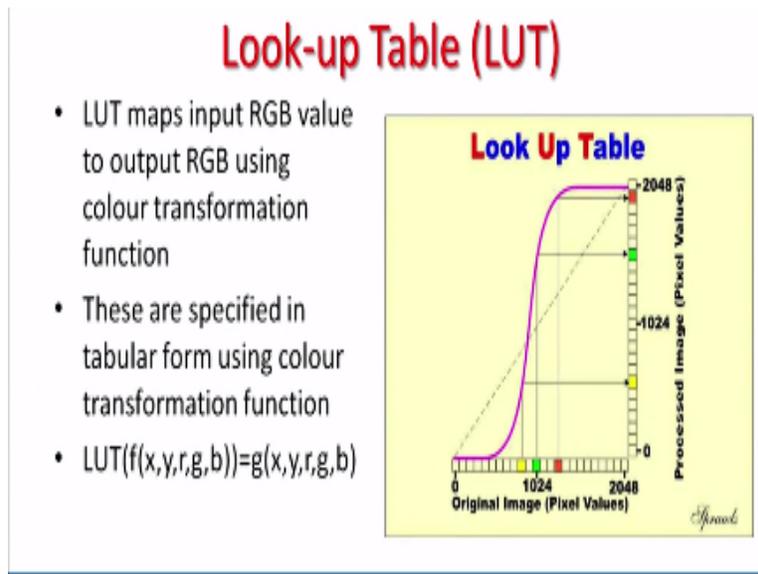
One other thing which we also use which is quite close to histogram kind of thing which we call as look up table or LUT so I thought that I can also add this one within this lecture and the L U T allows us to display the values without changing the original value pixel values of an image so you are having sort of the table and each input pixel being with the distributed will be assigned a new value only for display.

So that is called as look up table then example is here a giving this is a instead of a 0 225 you are having mega example of 0 to 2048 and also on the by X axis is 0 to 22048 values are there and if the pixel value is having the say 500 or thousand values then the corresponding and the value for the display would be somewhere here so the LUT basically LUT maps the input RGB value to output RGV values may be LU T may be for the single band or may be color band .

So color image using a color transformation function and these are specified in tabular form using the color transformation function that the function is very simple that LUT with through

this function while RGV = g{x,y,r,g,b} so you can this allows the advantage of the LUT that it allows us do not change the values and the before display.

So your image is in depth your data is will remain always in take only for the display you will use LUT so that allows as kind of flexibility you can always see LUT instead of creating a new file of your oriental band because ultimately what evens because you are handling high special revolution and the data it occupy the lot of the space on your hard disk and nobody would like to have that one the best thing is to save LUT rather than a new enhanced image of the that band . So that is why the enhanced this is the LUT is very much required now how statistics can be extracted from these univariate descriptive image in statistics can be seen or extracted from these.

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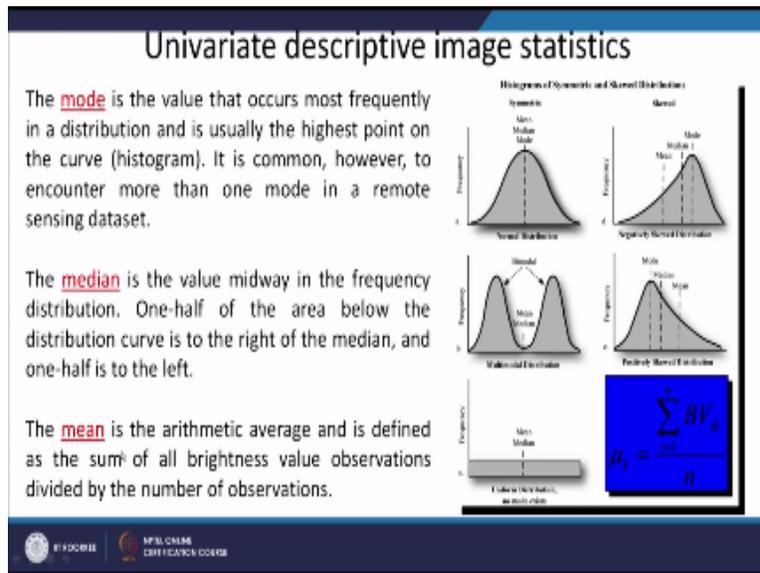
So I will go one by one first is like mode so if you said as normal distribution and having a full symmetry you will have a mean median and mode just one which is near natural good images here so the images which is having high contrast and another things you may not have a this kind of scenario but anyway so you are having it normal distribution you are mean median and mode are the same and if you are having a skewed distribution like in this example then mean is less median in between and mode will be having a higher value.

So this example of negatively skewed distribution and the lower one is positively skewed distribution we are mode is having again will have a lower value median and mean is having

higher value on X axis bimodal when your image is having two major areas having two distinct variations in the pixels values.

Then you may have a situation something like bimodal or multi modal distinguishing though the mean and median would be in centered but the bimodal will create a altogether differentiate of the program. And then mean and median are when you are having new form distribution that means all pixel values are same which is not a very rare which is a very rarer except images in desert areas you may have a distribution something like that so in the last lecture you look how mode mean and these are defined mode is a value that occurs more frequently in distribution and use early in highest point here you value the highest point here like the curve histogram.

It is common however to encounter more than one mode in a remote sensing datasets, like here we are having two mode. So this is bimodal scenario, so it is not necessary that you will always have one peak as I have been discussing depending on the areas which are being represented within one image.

So the histogram would be accordingly, second is the median is the value midway in the frequency distribution. So this is in case of normally distribution the midway value is the same as mean and mode, but in case of negatively skewed distribution median would be somewhere here. So the median with midway value for the frequency distribution one-half of the area below the distribution curve is to the right of the median and the one-half is on the left.

So if median is plotted then, because it exploiting the distribution or the frequency of your pixel values as well it incorporates that one. So it is the median of the frequency as one-half is having one number of pixels and another is the same number of pixels. And the mean is simple arithmetic average and is defined the sum of all brightness value observation divided by number of observations which are displayed here.

So basically this brings to the end of this discussion that how histogram and bivariate plot LUTs can be exploited, can be used before we go for serious image announcement technique. They will allow us to first to understand how pixel values are distributed of within one image may be a single bend of multiple bend depending on what kind of analysis we are going to perform. And then it will also allow us to understand or to choose that how the announcement can be performed so that which image announcement technique will be adopted.

So that is why histogram bivariate plot and LUTs these are all important steps before serious image announcement procedures which we go for image announcement, so that you very much.

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