Biometrics
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Lecture No. # 05
Spatial Filtering

So, today actually we are planning to discuss about the image sharpening, which is one of the important features, or image processing, or image operations, which will be needing very frequently for biometrics, it is a system design.

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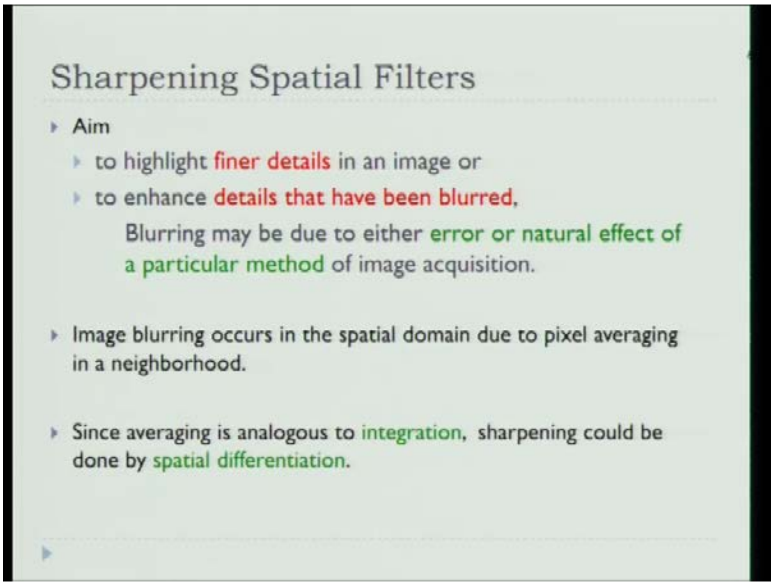

So, the sharpening is also one kind of filtering technique, and it is also you can achieve through coagulation, what is your aim? Aim is that you have the finer details in the image, those finer details you want to sharpen ,there is a thing, you want to make it more bright, you want to make it more highlight and so on, or there may be some area where due to some reasons it has become blurred, you want to highlight it or you want to enhance that blurred part.

Now, this blur can occur, because of the naturally fact what does it pick, that you have used one camera, and that camera is giving you the image with a blurring with a smooth effect, smoothing smoothen one, but you which gives you the soft look of the on the image, but that may not be helpful you want to highlight the component which is say road I want to highlight the road component.

So, or because of some image processing operations performed the image, and due to that you got the blur. Say for example, we have considered already that average filtering technique, it takes the neighboring pixels to replace the central pixel, and as a result it creates the blurred image. So, average is nothing but some of neighboring pixel divided by the total widths, and obviously this is an analogue towards your integration. So, you want to dabbler the things; that means, you want to perform the reverse operations, that means, you need to do something similar to differentiation, which will give you the shaped image, shaped component. So that is your aim; that means, you need to know what is the behavior of the derivatives.

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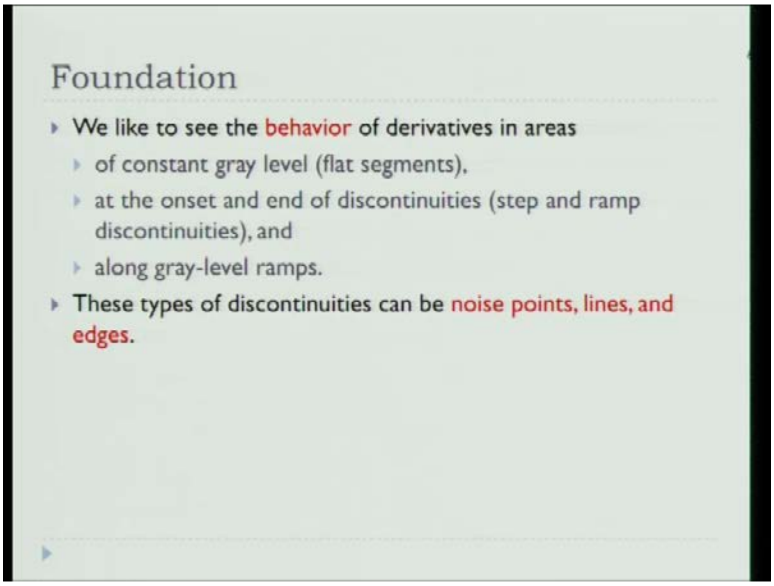

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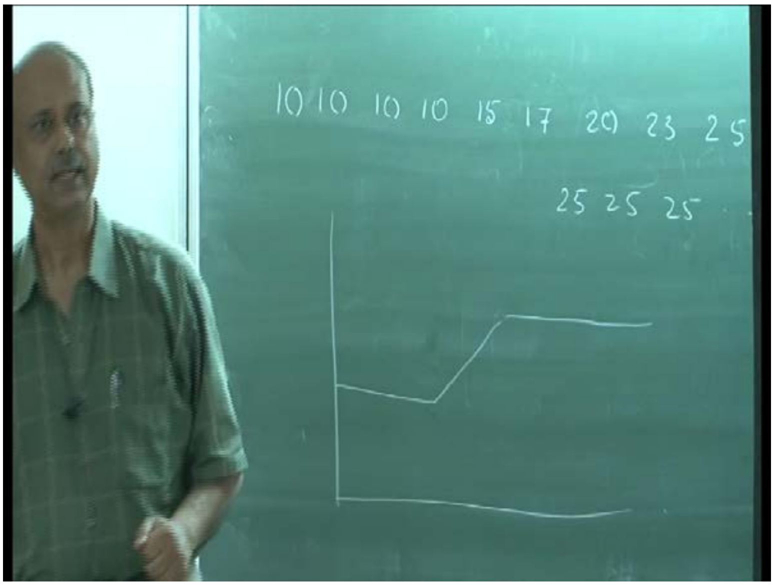

Now, consider the gray values of say 1 row. So, maybe it is like that 10, 10, 10, 10, and may be 15, 17, 20, 23, 25, and then continuously it is 25, 25, 25 and so on. This is the gray values or intensity values of a row in an image what it gives, that if I see that plot it here it will go like this 10, 10, 10, 15, 20, 17, 23, 25 like this. So, what is the behavior here, if I think about the derivatives, what is the behavior here or here at these points? This is the discontinuity point here or this here what is the behavior if I think about the derivatives, or what will be the behavior in this area where increasing that ramp is there this are the derivative will give you some information about the structure. Now this type of situation will occur when there is a little noise maybe, maybe there is an edge, maybe there is a line in between and so on. So, this is the scenario.

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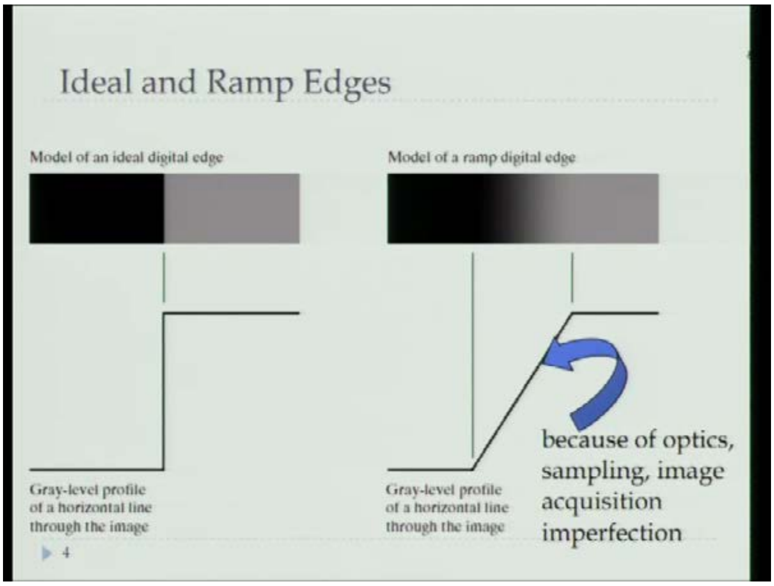

So, ideal digital image if I want to get a sharpened sharp line, then I should have got from black to white straightway then you will be getting the sharp line this is the ideal scenario, that if I want a line here a sharp change between these two then they should be you know sudden change 0 to 1, or 0 to 255 it cannot be 0, 0, 0, 0, then 17, 19, 20, 30, and so on, and it finally, 255 this is a ideal scenario, but in reality you will find that it is not sharp change it is not sudden change it comes slowly changing and so on.

So, this slow change maybe because of your camera, because of the optics, because of your image operations you perform on it. And that is this is your ramp component, now this ramp component plays an important role to understand the sharpened image or not, is not sharp image.

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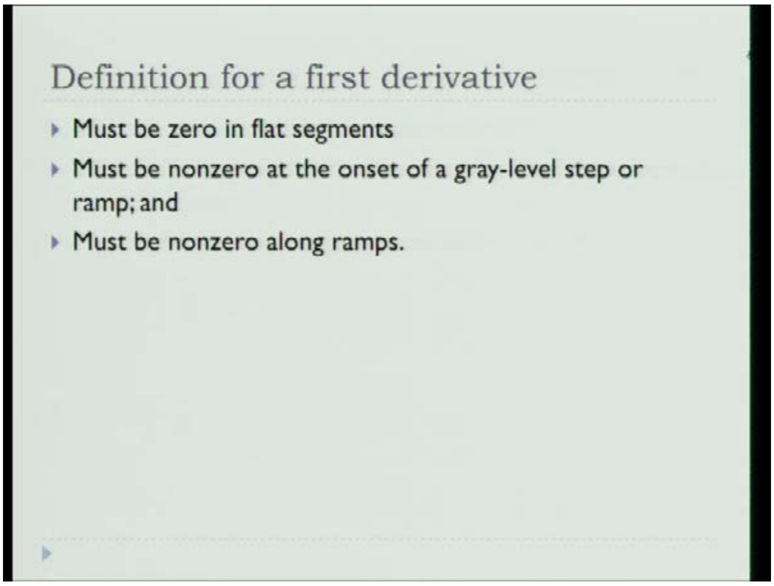

So, you observed that if I take the first derivative on the constant values there is no change so, the you will get the first derivative be zero, here at this point first or at this point the first derivative will give you the nonzero, and when it is on the ramp, there no you will get the first derivative nonzero elements. So, when it is constant intensity value is constant the first derivative will give you the zero values when at the onset of the gray levels step or ramp just here you will get the nonzero values in the first derivative, and also here also will get the first derivative zero, but this is not the case with the second derivative when the constant intensity level change in the level change is constant, you will get the zero when it is here the second derivative also will get zero, but at these two points you will not get zero.

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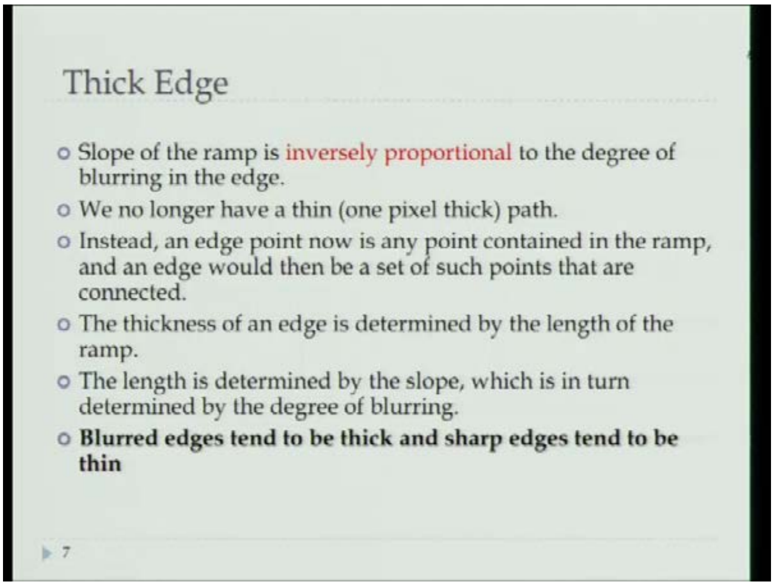

Now, this slope of the ramp will help you to understand the degree of blur, see if it is a sharp one if it is the sharp one that constant gray values here and after the sudden change, and you got the gray values like this. The slope will be what? slope will be 90 degree, and the slope is more, and degree of blurring effect will be less. So, they are inversely related.

So, as I told you that in reality you will not get this type of thing, you will get this type of thing. So, if the image is sharp then you will get the only one pixel jump, for that intensive level is 0, 0, 0, 0, and then suddenly 255, 255, 255, but see it will not be one pixel jump, it will get the several such pixels slowly it is going up. So, we no longer have a thin path instead, what you will be getting, you will be getting an edge point on this ramp that any point on the ramp will give you an edge point.

Now, edge will be giving you that you can tell this is an edge, when you have several such points which are connected, that will give you an edge otherwise it will be a noise just one point, and just jump it is a noise. Now what is the thickness of your edge, because as I told you that if it is a sudden jump then there is one pixel difference the thickness is single pixel, otherwise if it is of this ramp type then thickness of the edge is the length of this ramp.

Now, this length will be increased as the angle is small that slope is very less, if the slope is very less then angle will be this length will be more length will be more so, length will be depended on the slope, and this length will be less this length will be less showing it is thickness is less. So, edge thickness is dependent on the slope of the image, slope of the ramp, and that means, that edge thickness is dependent on the length of the ramp, or can I draw now further that edge thickness will give you the degree of blurriness, because as I told you that the as the slope is less blurring effect is more. So, this length will tell you the how much blur it is. So, edge thickness will give you the degree of blurriness agreed.

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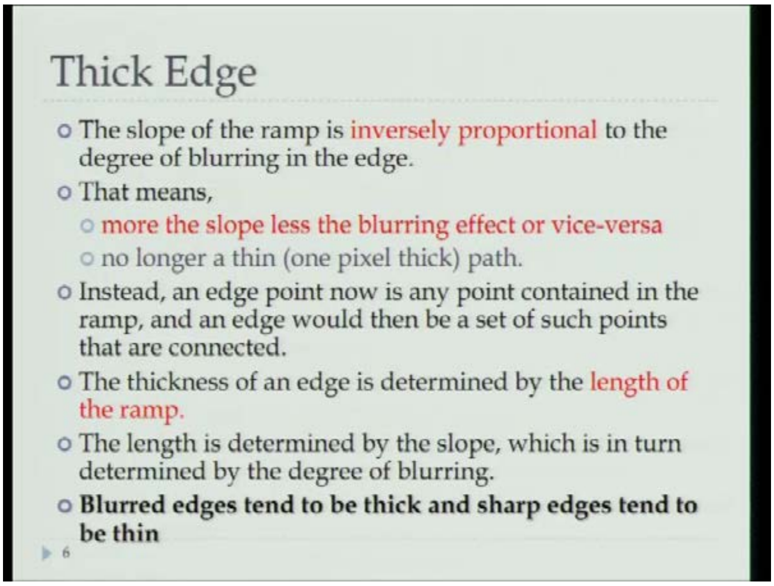

So, if you have an edge this thickness is like that; that means, the blurring effect is more so, blurred edges tend to be thick while sharp edges tend to be thin remember in the case of the problem is I want to get the sharp image, I want to get the sharp image means I want to get the sharp area on the details where you want to attack, you want to see the railway line, or you want to see the airport. So, boundary of the airport should be sharp and so that you can understand that this is an airport.

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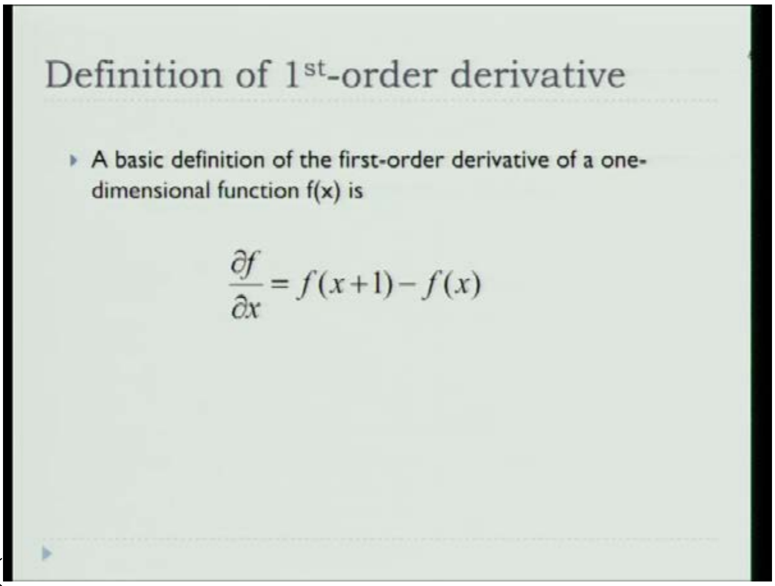

Now, as you know that in the case of because you know you cannot think about the continuous straight domain, it should be it should be on the discreet domain. The first order derivative is del f divided by del x and which is f x plus 1 minus f (x).

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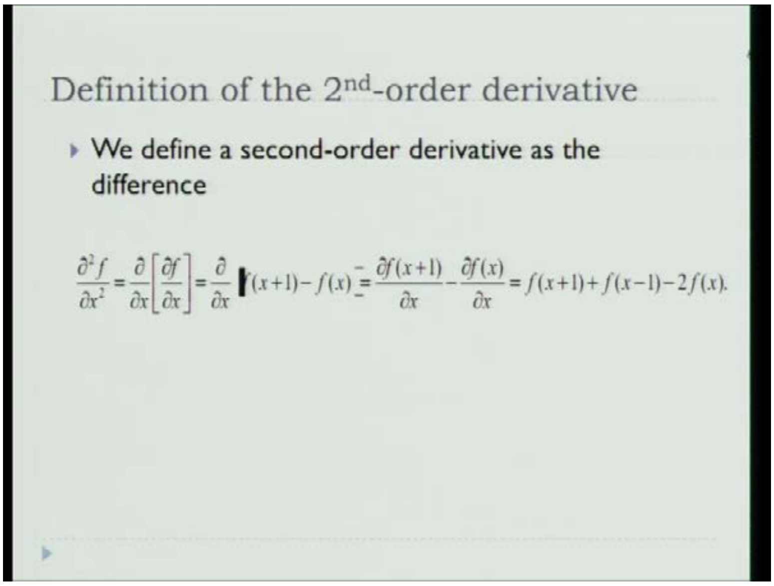

And, if I go for the second order derivative along the x del x square f divided by del x square, and if I proceed like that then you will get f of x plus 1 minus 2 f x plus f of x minus 1. So, this is along the x axis similarly, you can think about along the y axis.

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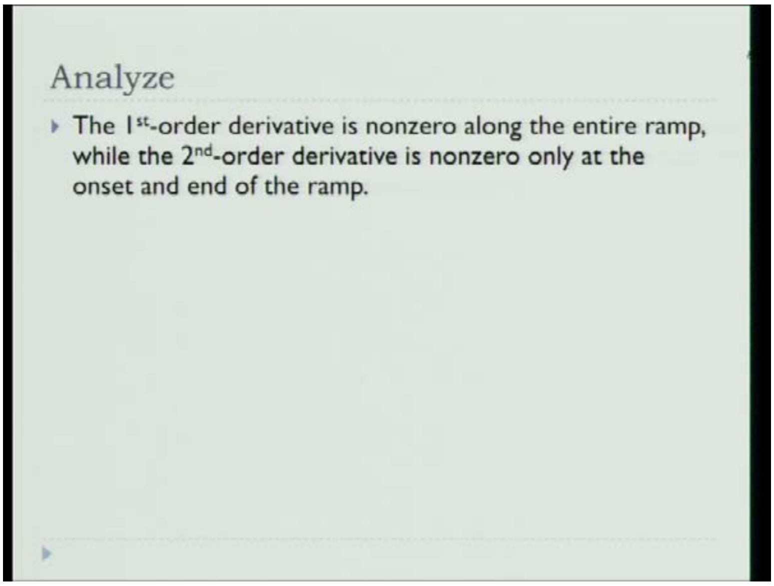

Now, if you analyze this one that what we have seen the first order derivative will give you the nonzero from here to here nonzero coefficient nonzero values, but this is not the case with the second order derivative it will give you the nonzero at this point only this is the thing what we understood.

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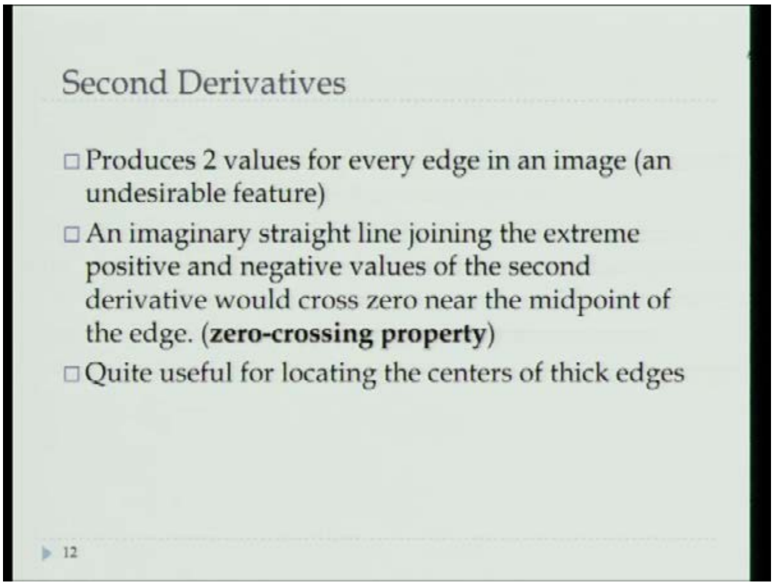

So, what you will get in the second derivative, if I first derivative k is if you see this is your original image, and if you see that there is a first derivative case you will get the lines like this, but if I take the second derivative only the nonzero values will be coming here and here where about there is a change, otherwise all of them are zeros.

So, the second derivative case it produces the two values I will check you know that diagram will help you to understand I will do that, second derivative produces the two values for every edge in the image. Now if I think about a line connecting these 2 points, this will cross the zero area and this is known as zero cross edge we will be using very frequently this term, this is a zero crossing property, now this zero crossing property will help you to understand or to get you the estimated center point of the thick line, thick edge. So, this is, this helps you that once my thick line is like the thick edge is like that I can estimate the center of this center point of the thick image, because thus that is required if I want to obtain a thin image, out of the thin edge, out of the thick edge.

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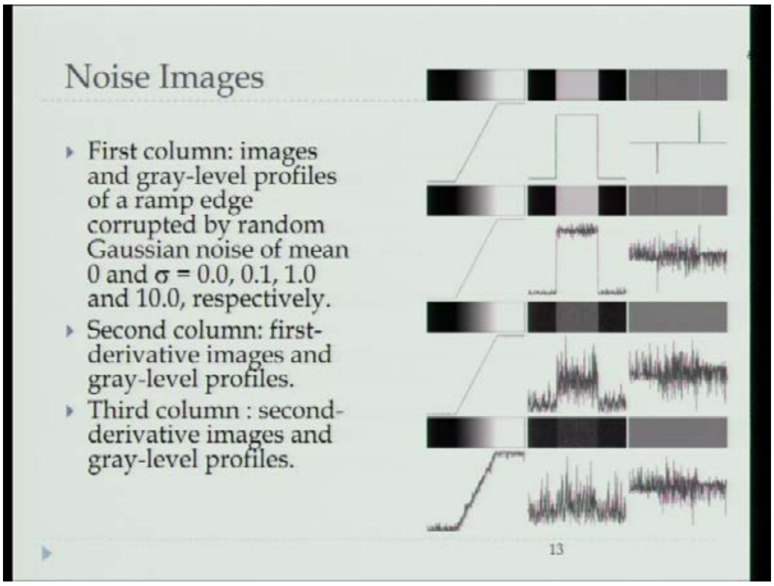

This is one example, this is your original image, this is the first derivative one, and then this is the second derivative one. So, this is the thing I was talking about this is the original ramp, and the first derivative will look like this second derivative of this case is coming like this. Now, we added some Gaussian noise random Gaussian noise with mean zero or sigma this, then image will look like this, and the first derivative will be of this all type, and the second derivative will give level profile will be like this, and this is the case with different types of noises after adding different types of Gaussian noises will be getting like that.

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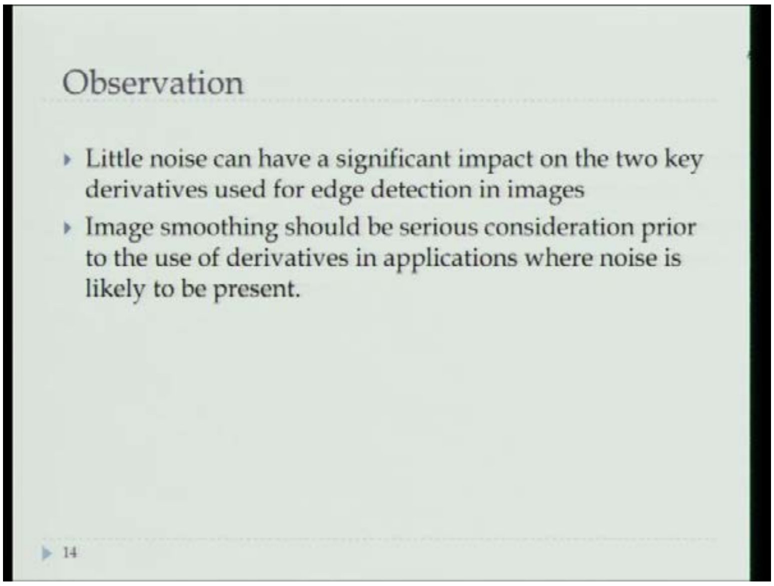

So, what you observed that I if I add simple noise into that very small quantity of noise, it is creating havoc on your first derivative, and second derivative, see by adding small noise see the first derivative and second derivative structure. So, it creates a problem for you. So, if there is a little noise or some salt and pepper noise you, and you remain is that first derivative and second derivative may not give you the good indications or about your nonzero components. So, what is suggested that you first smooth the image by some method before you think about the derivatives.

So, first you smooth the image by some method, say average filtering is also is there or any method once you do it that noise will be gone then you perform your that first derivative or second derivative.

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Now, this Laplacian filter it is a second order derivative, the simplest isotropic derivative operator is given by del square f del x square divided by del square f divided by del x y square. So, isotropic means that it keeps the property along both the directions and along all the directions basically, x directions, and y directions. So, that is the thing what we have taken that this derivative and also with respect to y.

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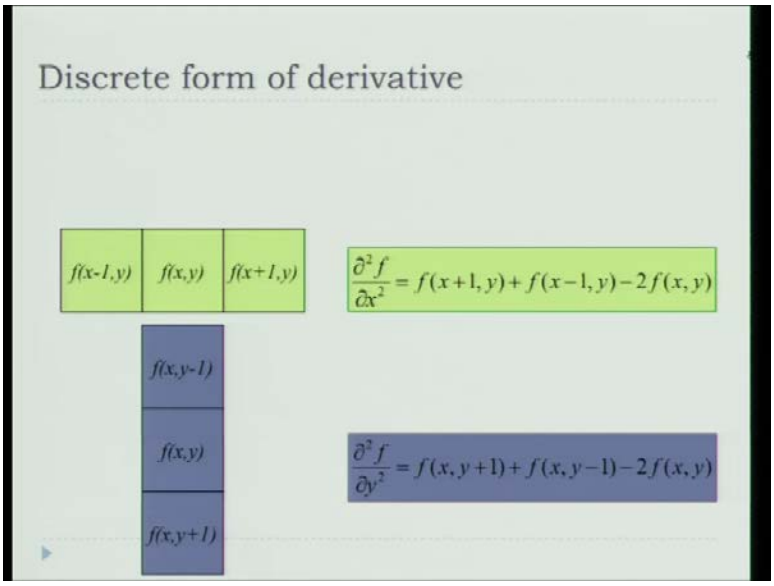

If, we look into that del f del square f divided by del x square, you will be getting this one, right these are the three points now I have to compute this 1. So, from the derivative second derivative we got this formula; that means, this 1 plus this 1 minus twice of this 1. Now, if I have follow if the along y directions then this 1 plus this 1 minus twice of this one that will give you the second order derivative along the y.

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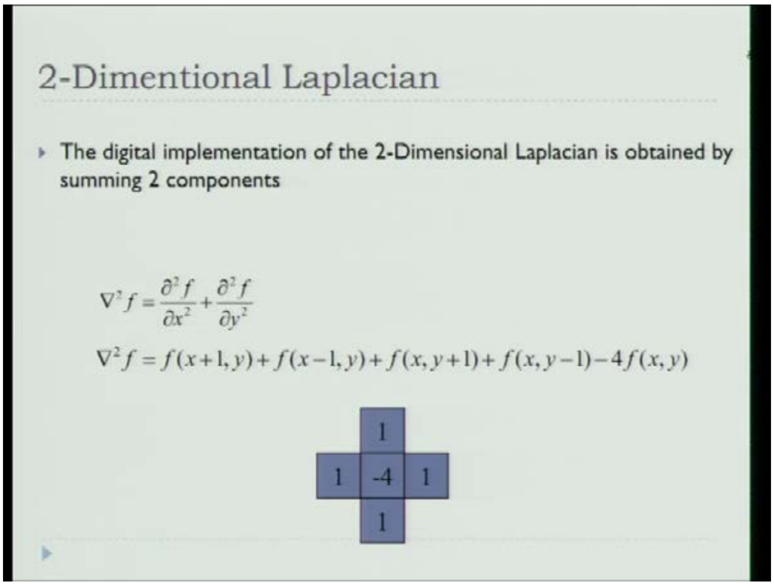

So, if you remember the formula is nothing but the sum of these two sum of these two. So, if I combine this that del square f divide by del x square plus del square f divided by del y square, you will be getting that, f of x plus 1 y plus f of x minus 1 y plus f of x y plus 1 plus f of x y minus 1 minus 4 times of f(x, y), and this I can write as a my cardinal 0, 1, 0, 1, minus 4, 0, minus 4, 1, and then 0, 1, 0. So, this is the cardinal you will be moving from the left of corner to the right bottom most points.

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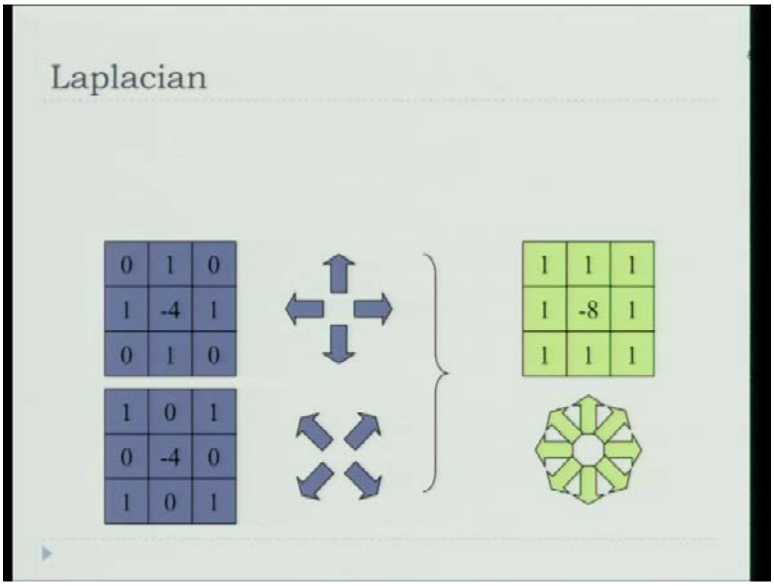

Now, if you observe this cardinal was taking care x directions, and vertical and horizontally I could have thought that no I want to give the importance on the diagonal so, this gives you the diagonals. If I add both of them then I will get all eight directions so, the cardinal becomes 1, 1, 1, 1, minus 8, 1, 1, 1, 1.

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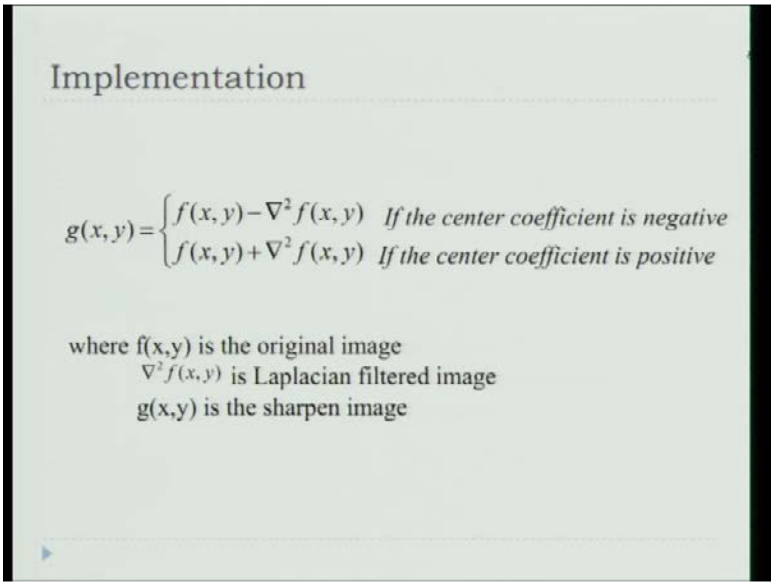

That cardinal gives you that whatever second derivative you got, along the x direction, and along the y directions. So, if I subtract that one from the original image, that one from the original image, I will get the sharpen image, that to get the sharpen component that second derivative will subtracting from the original image. Now this subtraction is coming when the central pixel is central cardinal value coefficient is minus, if it is a plus 1; that means, you have to add sharpen image is nothing but f of x y minus del square f(x, y), when the central pixel or center coefficient is negative, when center coefficient is positive then it is f of x y plus del square f(x, y).

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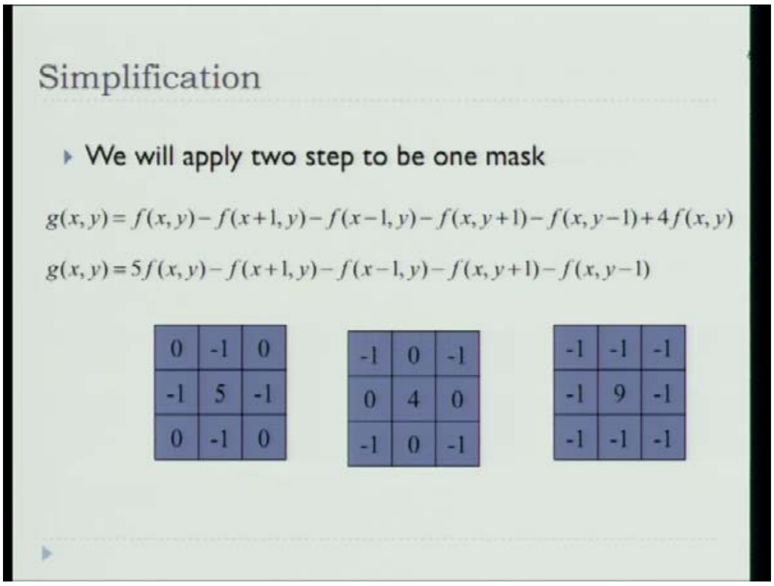

So, if now you know the formula you know the value of this, that is nothing but f of x minus 1 y plus f of x plus 1 y that formula is known, if I put it if we put this value then f of x y minus this if I put this value I will get this value, with minus del square formula if I put this in minus formula, and combining this I will get this 5 of f x y minus this so, this gives you the cardinal of this form. So, this has come from this formula that I have just put the value of del square f(x, y) here then you will get the equation 5 of f(x, y) formula.

Same is the case if you put this 1 here. So, you get 0, minus 1, 0, minus 1, 5, minus 1, 0, minus 1, 0. Now suppose I want to add the no I want all eight directions then obviously, this cardinal has to be added along with this. So, finally, you will be getting minus 1, minus 1, minus 1, 9, minus 1, minus 1, minus 1, minus 1, you could have thought no this or this is minus these are all plus so, there the what you will be getting. So, one thing you remember that this sum of all the coefficients is giving you the value one, what it gives you the idea that brightness is retain average brightness of the image will be retain right that is from the definition whatever we have discussed earlier.

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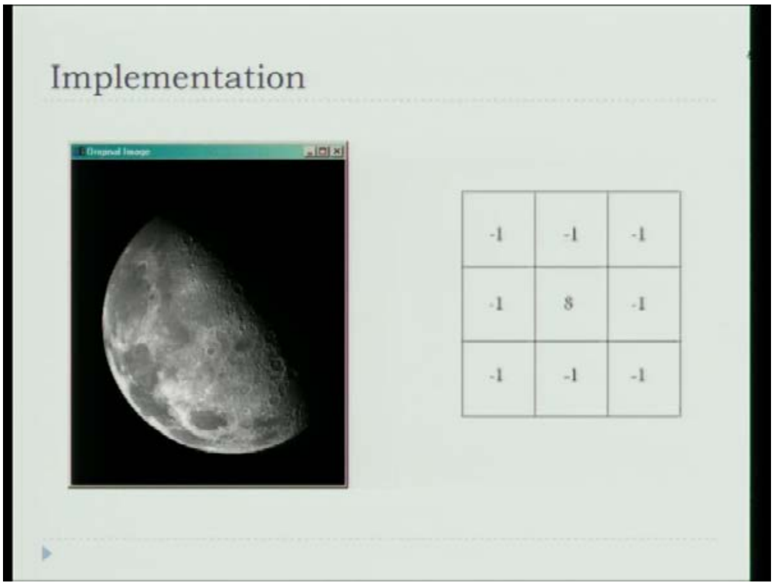

Now, this one example I took that this is the original image of Mars, and then you have put this cardinal, and you get the g value of derivative once filtered Laplacian filtered values.

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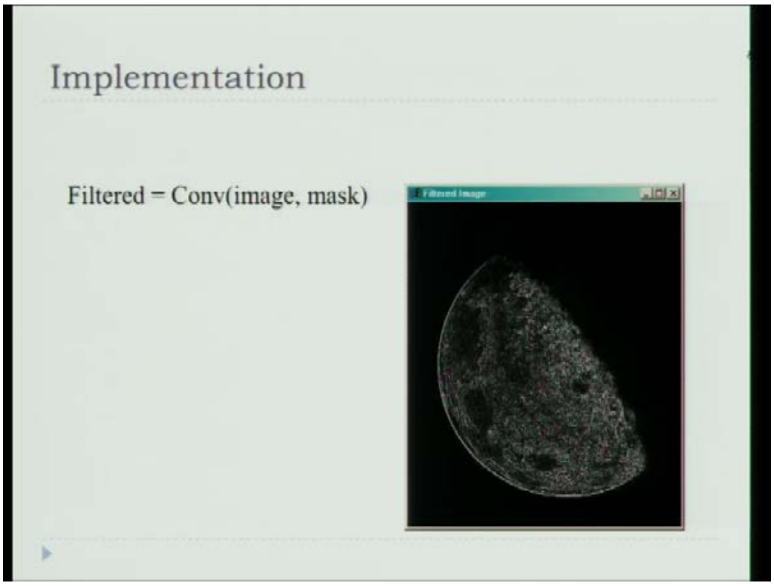

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So, what you do basically first you obtain the you perform the Laplacian of filter on the image, and then you will be adding that value or that filtered image with the original image to get the sharpened image.

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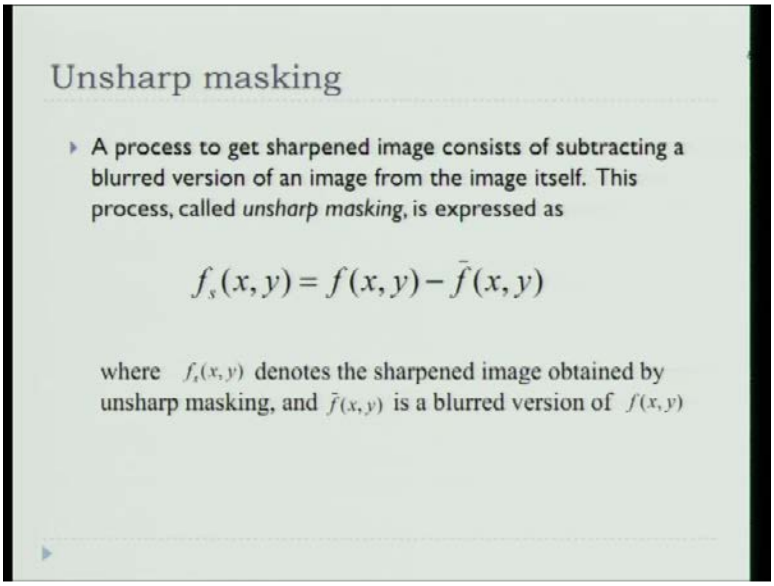

Now, if you see that we will need to find out I want to get the sharpened, I want to get the sharpened image that is whatever half Laplacian filter component you got I want to get it from the image f(x, y). So, image original image f(x, y) is given to you, and if I subtract the blur component that should give me the sharpened image, image or not that you have the original image the blurring part I want to subtract from it, I should get the sharpened image; yes, see from the definition itself it is there where I wrote the g(x, y).

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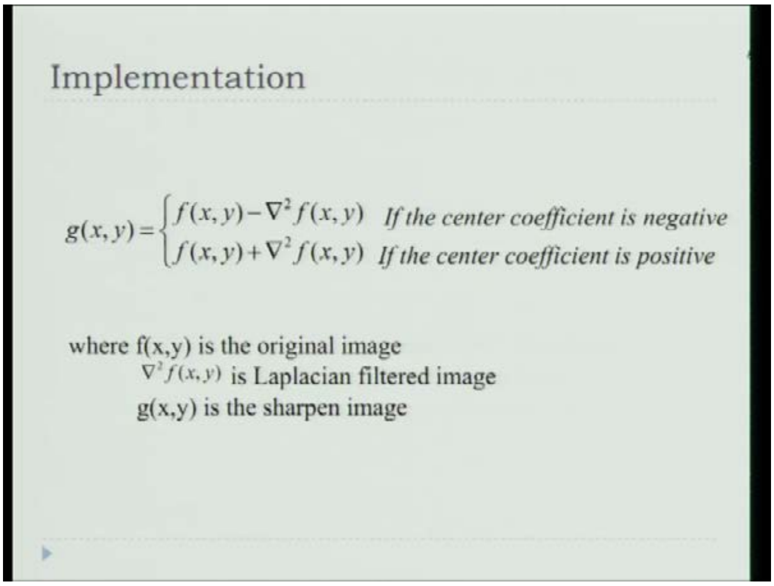

So, g(x, y) is equals to f of x y minus the filtered image. So, I need to get this filtered image. So, what I would be doing that f x one minus f x y minus g(x, y) will give me this, g(x, y) is your sharpen one sharpen image. So, unsharpened it if I have to unsharpened it just I have to subtract g(x, y) from f(x, y) what is g(x, y)? g(x, y) is a blurred image.

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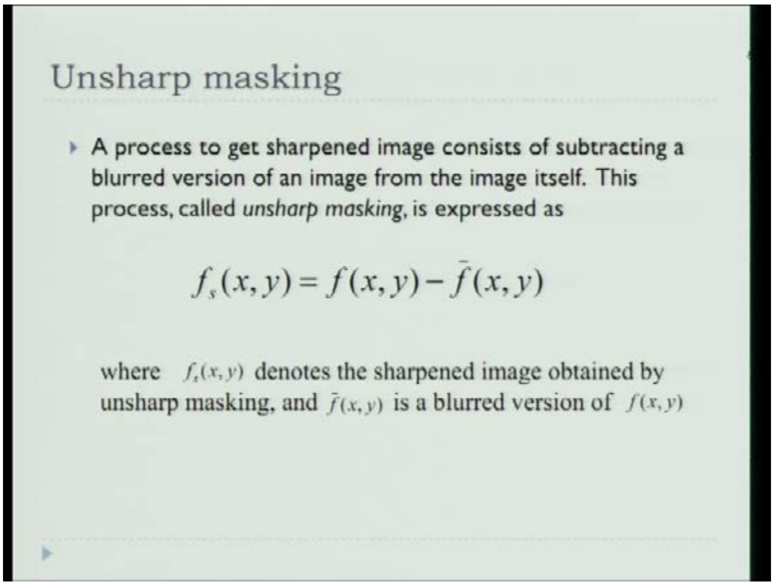

So, the blurred image if I subtract from the original image I should get the sharpened image. So, how to get the blurred image blurred image one way could be that you take the average of the neighboring pixel, or in nature you got the blur image through your camera the camera is always giving you a blurred image, that blur image and original blurred image whatever you have after performing the pre-processing operation you just subtract it you will be getting the sharpened component.

So, if I know this f x y minus f bar x y, that if I subtract that blurred image from f(x, y) what are you going to get? say I have the face image, and I have taken the under one is hat control environment another one is that under different illumination effect. Now the different illumination or illuminated one, you have taken the average of you obtain the average image, then if I subtract it from the control environment what you will be getting, that illuminated effect will be gone, is it ok at the illumination image, and I am subtracting the average image then illumination effect will be gone, reflection parameter would be eliminated.

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So, that is the thing we need to do what we do in the palm image, given original palm image, and then I obtain the average of this say, I have the palm image here, and I divided into the several blocks I obtain the average of this all the values I put it here average of this value put it here. So, I obtain the average of each blocks average of these blocks. Now, this average I replicate all into whole sub blocks. So, this average is here, this average is here, this block consisting of the average intensity value of this block, now if I subtract this one from the original image, what you are going to get that whatever extra things is there that will be eliminated, you will be getting the true value.

Now, one problem you will be facing if you think this way that if I subtract the average value, from the original value, there is a possibility there some will become the negative values, and some will be the positive values, and also the values may be very less if I subtract the average value from the average value of the block from every intensity value of that block, you may find the values will some of them may be negative, and some of them may be positive, and the range of the values may be very less, and as a result what will happen that image will become very dull and you know dark it will be a dark image or since the negative value is here an eight bit negative value because I m assuming that this I and t in form. So, it would may give you very sharp very white color.

So, what is the best method before you look for the image, or before you like to see that one you first find out the minimum and maximum, and then we discuss how to stretch it to make it 0 to 255 range, then the image become that usual normal image after subtracting the illumination parameter or reflection parameter.

See, this in the case of palm it become very useful, because if you see that you know palm there some part of the palm is not flat there little oval shape. So, you may not get the good may not get the good illumination free images. So, the idea is that by seeing the image specially you will find when you are taking the photographs the non control environment, see our problem whatever image we have in our lab they are all under control environment, but in the anyway nobody will accept research component if I forget about the research part, but if I have to tell that we have developed something they will not tell you that this is a control environment give me the data, and then I will go for committing crime, and then I will come and give my data again under control environment and then you match it this is not the in real life.

Real life is that you do not know, where from you will be getting the data, and who collects the data you cannot give the instruction that yes you have to get the data under this condition the person who is collecting the data, he may not knows how to collect the data he has to he has been asked to collect the data, he is collecting the data. Say for example, I can give you one example here that if you go to the is the police area they when they get the culprit or suspected culprit they take the photographs, and this photographs they keep it in such a first thing that they do not know how to collect the photo they have supposed to take the photograph they collect the photograph just take the front face side face and they put it in the notice board with a stamp. Now they put the stamp in such places where that whole image is gone basically it is useless for us to evaluate or to match with a another photograph because the stamp may be on the whole face.

Now, how to remove the noise from that whole phase itself, because if you remove the stamp from the whole phase then may be some important properties also you will be missing or you will be eliminating and the court of law they will tell that yes you have spoiled the image how can you tell that this is the same person. So, same thing happens if you see that your I do not know nowadays whether they put the stamp on your eye card or not. So, the person who puts the stamp on eye card, he does not care where to put the stamp he puts the stamp, it may be on your whole face, and it may not be useful at all later on to identify whether he is the man or not. So, so this under control we are thinking that the image will be under control environment it is not the case so, when you go to the field real field you have to eliminate something you have to perform the operations sharpening operations, so that you can eliminate some of the such factors

Say for example, I take your photograph fingerprints after taking the lunch suppose I collect your I am assuming now you are using finger hand to take your food, then after soon after your lunch I want to take your finger print data what will happen irrespective how much quantity of soap you use to clean your hand, but oily stuff will be there on your hand, and that is that creates the problem on my scanner you give the data first thing is data it will smudge, your data will be smudge that whatever value they will smudge

Second component is that you have given your data you have left, now the second person has come his hand is also oily thing greasy materials are there and he has put it, and you have also kept greasy intensity things on the because I have not cleaned it also properly. So, those will create the some false images on my original data. So, like this is the real scenario. So, you have to see or you have to remove those false image lines, one thing is sure that whatever you will be giving and whatever that your predecessor has given you there is a difference your thing will be more sharp compare to the predecessor he has already left and he has his thing the person concern he will be removing he will try to remove, but then also the symbol is there or the signal will be there. So, you have to sharp your image accordingly.

So, this if you see remember that if we have the image where your fingerprint is here, and lines are here, and then are some lines which are in light or low intensity lines will be there. So, this average, or if you do the smoothing operations or you will find that this will be gone, because they say this would become the noise and this would eliminated through mean filtering or average filtering.

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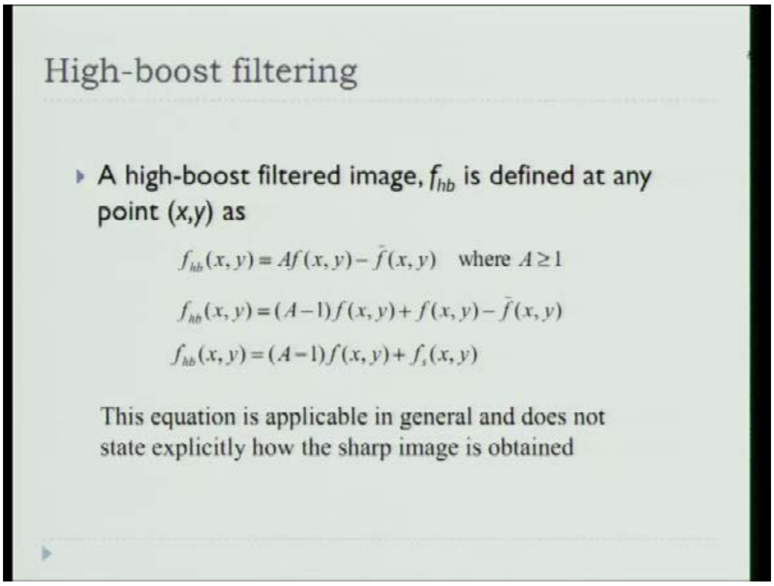

Now, why to put why to put only the original image f(x, y), what I want that I first boost it that f(x, y) by some constant, then you subtract the blurred one. So, what I am telling that multiplying by a calm constant which is greater than one with the original image, then I am subtracting that is the thing it told that, what I did if I do not multiply it, then there is a possibility the value will come or come down very small, and some of them will be negative some of them will be positive so, all sorts of things will be there.

So, you saw that I multiply it by some factor then I am subtracting the average one. So, if I can rewrite it a minus one f x y plus f x y minus f bar x y, now this f x y minus f bar x y will be giving you the sharpened image, because that is the formula we got from the previous slide f x y minus f bar of y. So, you get a minus 1, f x y plus the sharpened component. So, this selection of a is important you have to select a in such a way that it maintains that no one gets negative value and that white spread intensity levels are there.

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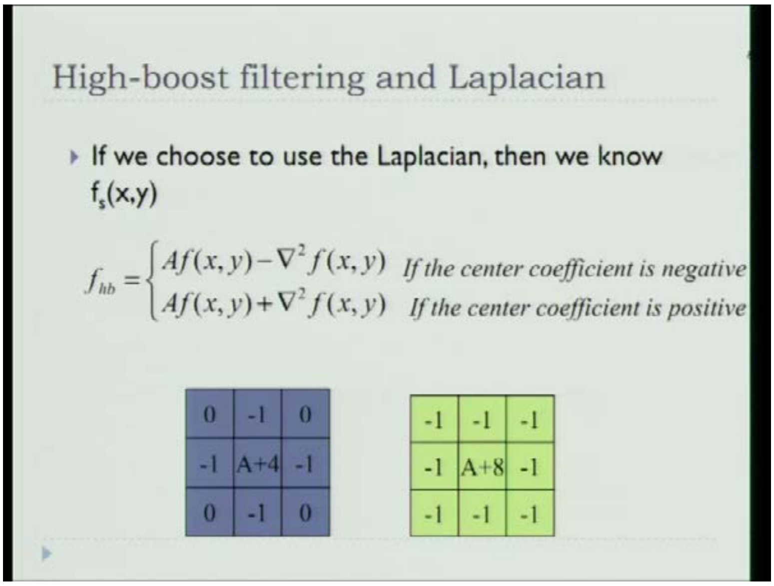

So, if I put in terms of Laplacian filtered then it is nothing but a time f x y, minus this Laplacian filtered, and which wise it is 0, because this is a Laplacian filter and this is A plus because it is a minus 1. So, A plus 4, and these are same things as it was 0, minus 1, 0, minus 1, A plus 4, minus 1, 0, minus 1, 0, if I consider the diagonal then this will become 0, this will become 0, this will become 0, this will become 0, this will become minus 1, this is minus 1, minus 1, and minus 1, and if I consider eight directions, then you will be getting minus 1, minus 1, minus 1, minus 1, A plus 8, minus 1, minus 1, minus 1, minus 1.

So, now what is the base value of A, the base value of A, should be what tell me. Now any idea? if A is equals to 1, then it is same thing you are doing only thing is that after subtracting there is a possibility, possibility of some negative value, and so that your aim should be such that you by seeing the image you have to see that what is your f bar what is your average things. Now average thing is almost similar to your original one then the question of A is should be increasing if average is very less than A can be written as it is because small value you are subtracting from the original one that is not a big thing.

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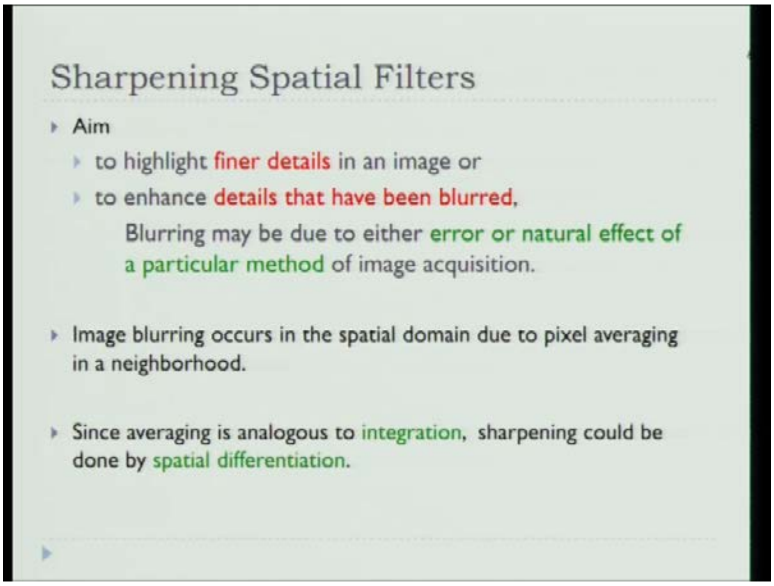

So, you have to understand you have to understand this average of this values, that is important you have the finer details you have to highlight the finite value that is your aim or if there is a blurred one, you want to highlight the blurred effect and blurring comes from this two one is the due to sum error, or due to some natural effect or the, because of some image operations and so, sharpening depends on the derivative because it is a blurring is the outcome of the averaging. Averaging is nothing but the integration that is whatever we have discussed. So, based on the how to obtain the derivatives and what is the impact using second derivative, and also we told that Laplacian operators, and use of Laplacian operator or filter to sharp the image or high-boost filtering techniques.

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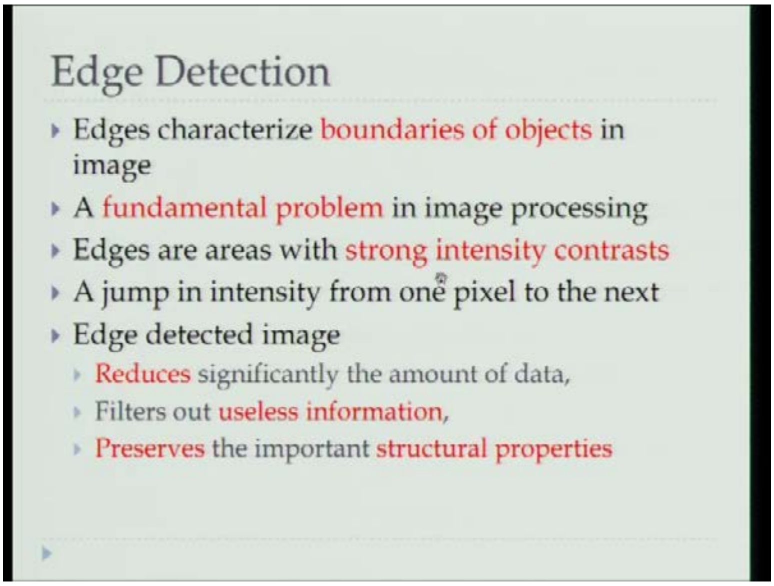

This is edge detection: Obviously that a by telling the term edge, edge is nothing but that what is the boundary of an objects where it has changed its intensity sharply. Now the definition of sharp is coming by now you know sharp, sharp change may be there, may not be there, because of blurring effect, because of thickness of the edge you may not thickness of the edge means, that the intensity value suddenly changing, slowly changing then you may not visualize that this is an so, the you have to sharpen the image to get or to realize that it is an edge, and of course, this edge detection technique is a one of the fundamental techniques, or this problem is detecting an age problem itself is a challenging one.

Edges of the areas with strong intensity contrast, a jump in intensity from one pixel to that next gives you the edge now once, I detect the edge what happens that I do not need to keep the whole image, I need to keep the edge of the image.

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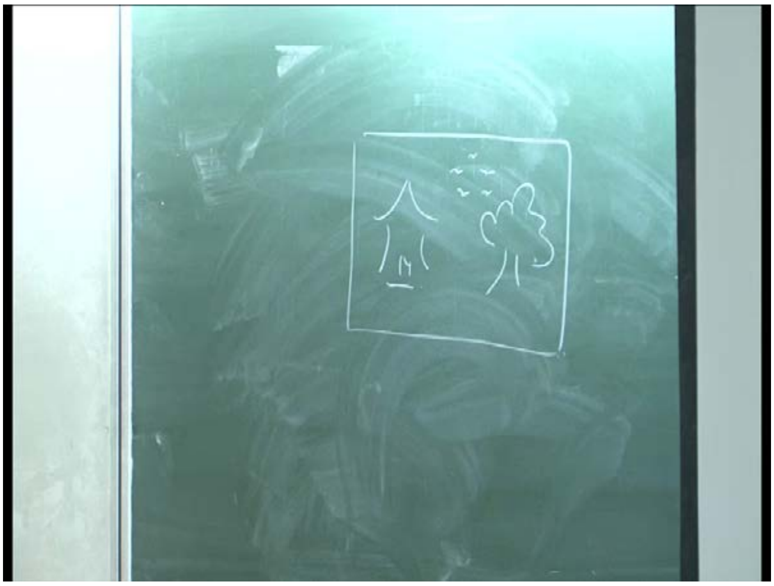

Suppose I have a house, something like that I do not know whether it is house or not, but I assume that this is house, and this is tree and some birds are there. Now, by seeing this also you can tell it is a house I am not given the color, I am not given other shape, only I have drawn some lines. So, this if I this are edges, and if I keep these edges it is sufficient for you to understand the imaged content, you do not need to you need to keep all the information or whatever you see in an image, and as a result you if I assume that you it is a binary image 0 and 1, and wherever the edge is there I put 1 rest of the things I put 0 then it is a big only base size will be reduced like anything.

And it filters out useless information whether there is a seepage in my house or not you will not be able to say, or shade is there or not those things. So, these are not required to understand the image; however, it retains the structural property it retains the structural property. Now, suppose is it possible to get back my color image again from there, is possible color image of my choice you, because those suppose if I put some pseudo color because if you remember in my one lecture I shown you some pseudo colored image with three another things. So, that we got an edge and that we put some color red RGB colors and then we combine it to show you the color.

So, if I put I know little knowledge is also now I need, I know that this is green. So, I put green these are little brown color, and this area I will put black, this I will put some combination of colors and you can see the house, may be it will give you the better look than your original house. So, it will preserve the important structural properties, but you may not get back your original look of the image.

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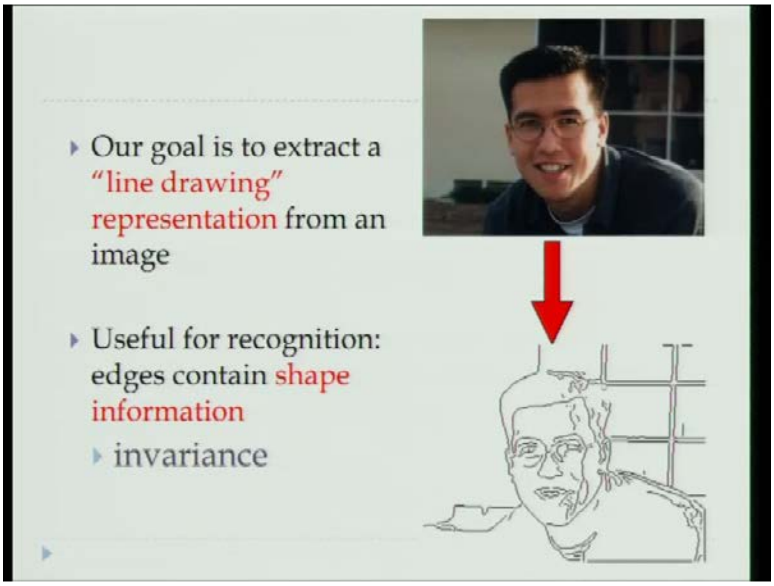

So, what is our goal? our goal is to extract a line drawing representation from an image. So, it keeps the shape information only, and the shape is you know it is invariance if I reduce the size then also you will get the same shape, if I increase it I should get so, if I have an edge and I will increase it shape will be there, it is invariance to another.

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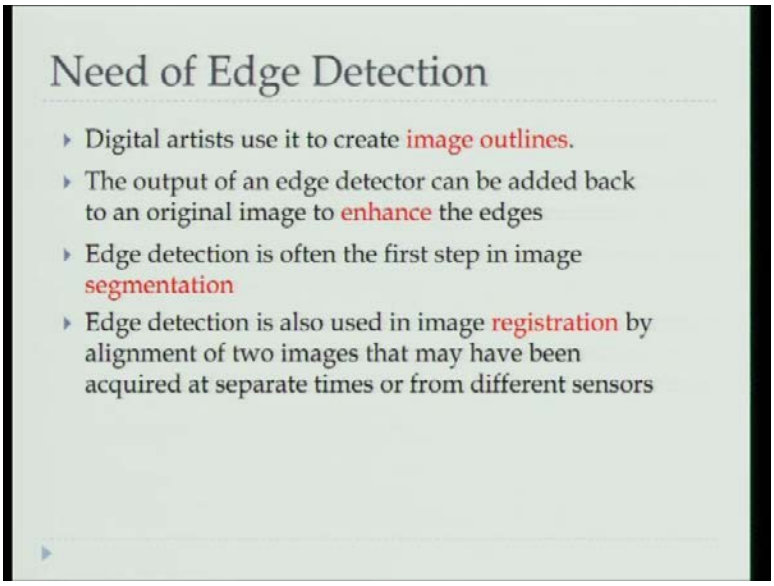

Now, why do you need the edge detection first one is as we told that it will reduce my size, and it would retain my structural properties and so, it gives me the outlines of the image it helps me to enhance the edges, suppose I get the structural property or I want to first enhance this image and then I superimpose on my original image you will find that it looks better. So, the output of an edge detector can be added back to the original image to enhance the edges, once I know this I will put say 255 values on this just I superimpose on it. So, this edges will be shown and then intensive value will give you 255 and so, you can enhance it.

Second one is very useful to segment something, it is very useful to segment the house from my image, I want to segment this part only house part say for example, I have the fingerprints four finger data you have taken, and I want to extract the point finger, middle finger, thumb, ring finger, or it a little finger, from my four slab image data. So, how to do it? so, first part is that you have to draw the or you have to obtain the edge, and from that edge you get the top of the fingers, now once you know the top of the fingers then you will get the other than the noise you will get the four top, and those four tops will indicate it these are your finger area from there you draw the lines, and then you can extract the because once you get the edge of the fingers. So, you get the top of this so, this four finger tips is known to you and this edge is known to you. So, you can extract this copyright segmentation you can segment the fingers.

The third one is most important one is that image registration. So, suppose you have the two images, and you want to register these two register means that you want to superimpose one on the another one, how to do? it say for example, I have one image say medical image and brain image you have and through MRI data MRI image you got one brain image another one may be CT scan or packed image. So, you want to on each

What you have taken at time t another 1 is say time t 2, now you want to superimpose you have to know that you have to match you know it is not guaranteed that both the image are of same exactly, same thing there is a little shift may be there you have to superimpose means you need to know some texture components, suppose I know this is texture this is another texture. So, so this point should map to this point should map to this, then you can superimpose on it, or you have the satellite image one path is like this.

So, you get the satellite image frames are like this, another path is like this is the frames now I want to get the larger image larger image. So, you got a frame and you got another frame they are overlapped now you have to register. So, that you get the bigger image bigger frame.

So, in order to do that you need to know some critical points, those critical points should be mapped with the two frames, and then you can set accordingly. So, that is known as image registration. So, there are three factor the edge detection will help you one in is the image enhancement. So, what you do? that edge detected edge you first improve the intensity then you superimpose on the original one you will find that edge will be very good fully and it is then image segmentation they have I have that if you want to segment the certain features, or some certain component from the image then segmentation will help you and finally, there two images you want for register that edging the edge will help you to do that.

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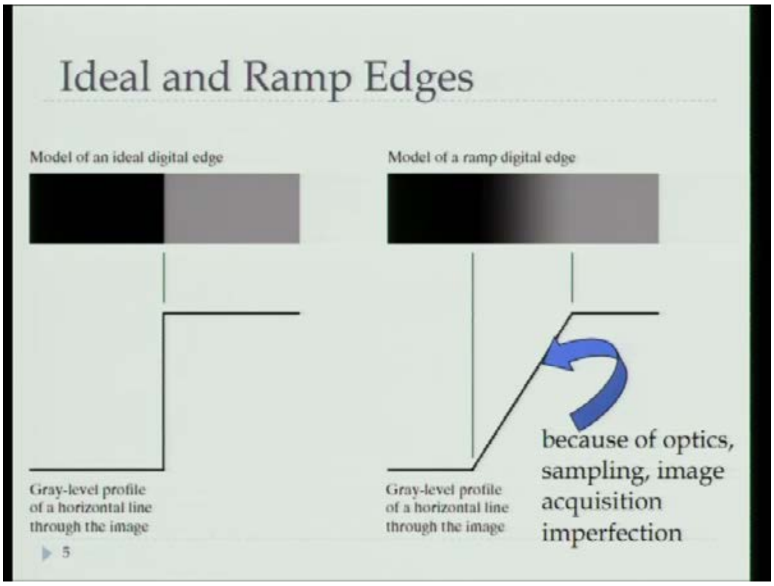

So, this is now I think I discussed that in ideal scenario the edge should be sharpened one, but in reality it is not you will find that there is a ramp, and ramp may be due to the poor quality of scanner may be due to the image acquisition technique, or may be due to the averaging and other image operation, processing operations.