Biometrics

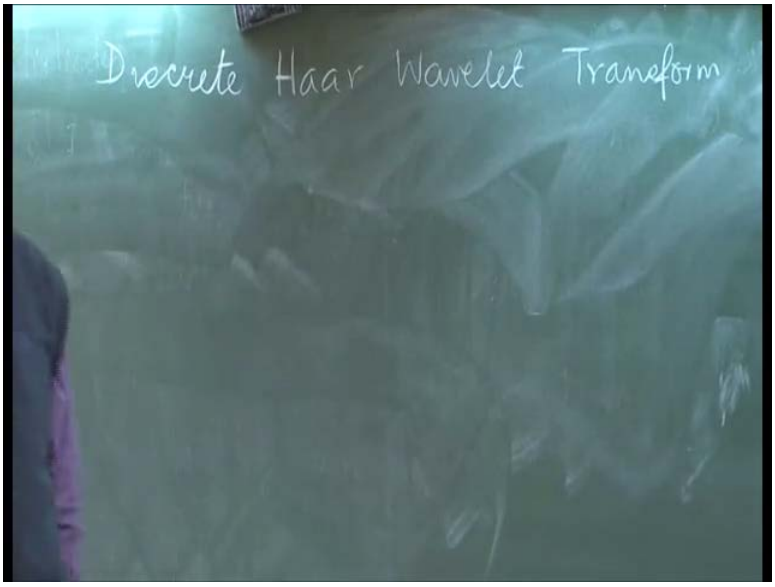
Prof. Phalguni Gupta

Department of Computer Science and Engineering

Indian Institute of Technology, Kanpur

Lecture no. # 18

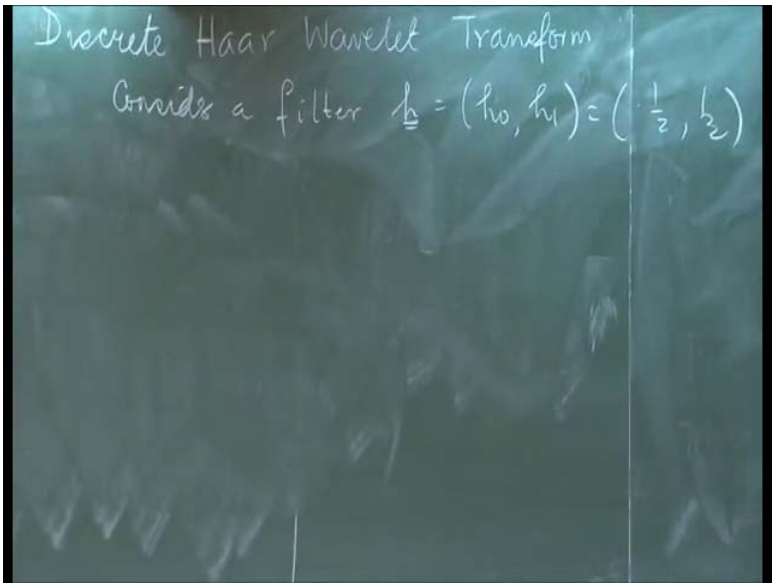
(Refer Slide Time: 00:16)



(No audio from 00:17 to 00:30)

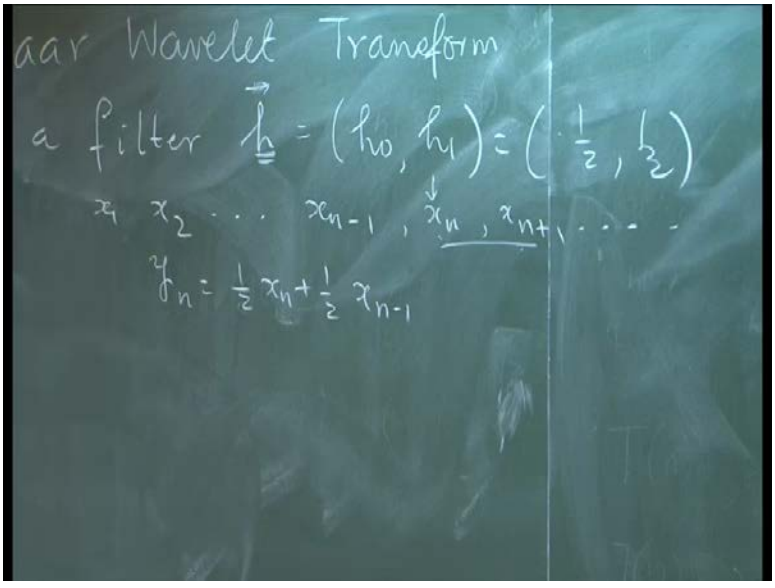
These are transformation, we will need to discuss because the face and ear, they are dependent on this Discrete Haar Wavelet Transform. Now, you know our image is a two dimensional. But let us start with the one-dimensional thing, then we will come to the two dimensional thing.

(Refer Slide Time: 01:03)



Consider just a simple filter consider a simple filter h and its mask is h 0 and h 1, which is this is actually it is a vector; vector is what? How you write this one? How do you write vector? This one; well the direction I do not consider. Anyway, h 0 and h 1 and this is half and half. So, if this filter exists and in an one-dimensional array.

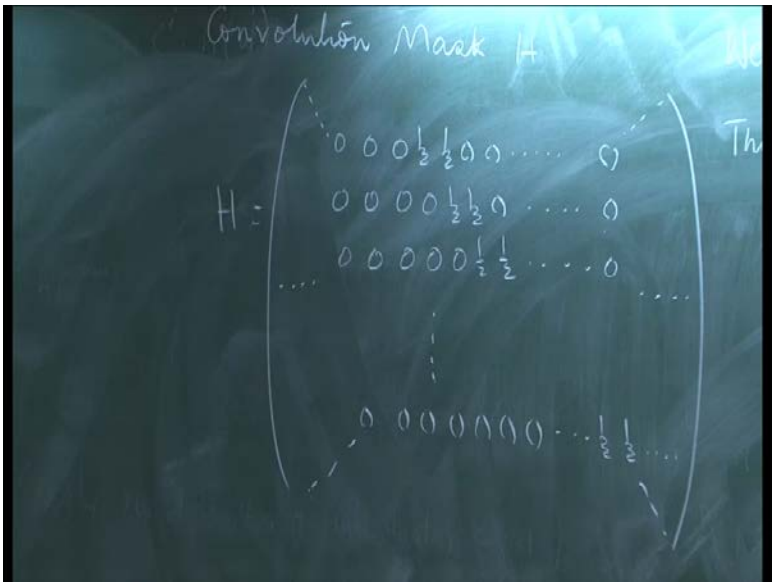
(Refer Slide Time: 01:50)



Suppose, you have x 1 x 2 x n minus 1 x n x n plus 1and so on and basically in this (( )) if I apply this mask here then you get y n is nothing but half x n plus half x n minus 1 and that is the meaning of this one is that their mask is moving with the coefficient half and

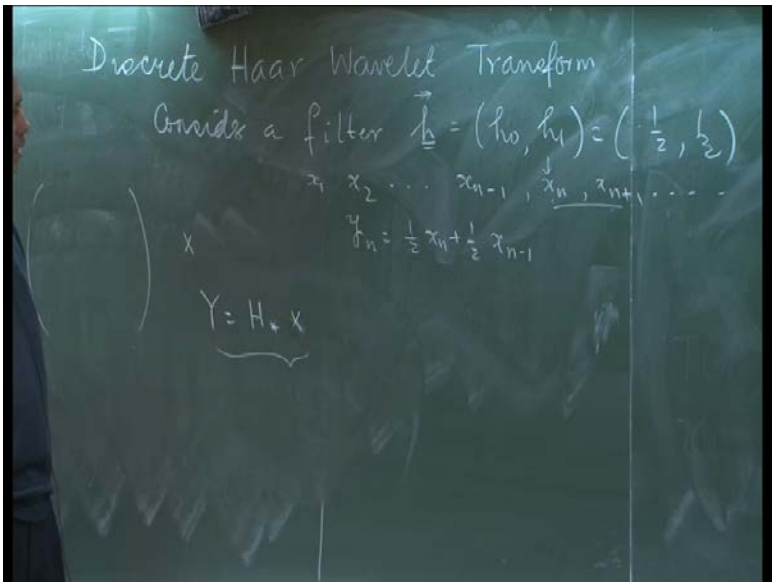
half. So, while I will be here to compute y to compute y n I will take half of this plus half of this, is it ok?

(Refer Slide Time: 02:33)



So, if I write in the form of convolution mask h, then h will look like this. So, this is our convolution mask. This will be moving basically this is your mask.

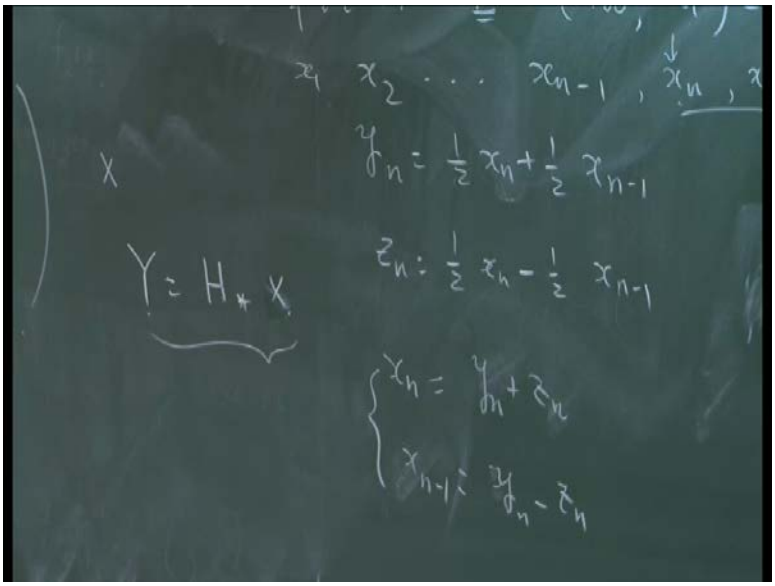
(Refer Slide Time: 03:45)



And, this is your x so, if you multiply it you will get your y n or y vector. So, y is nothing but here it is so I can write y is nothing but h into h into x. This will give your y agreed? Is it clear? Now, if I have this mask which can be written out y n equals to half

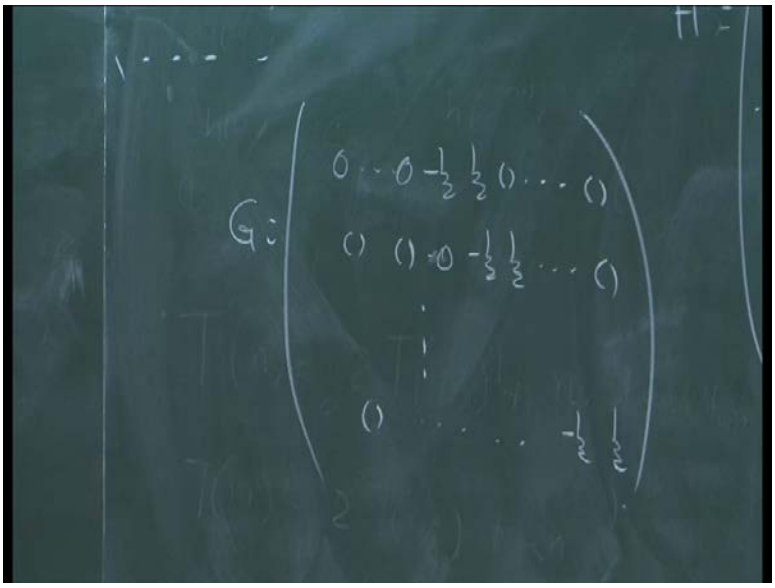
of x n plus half of x n minus 1 and this is basically you are taking the average of the two consecutive numbers to get the number. Is it ok? Is it invertible? Can I using this if I know y and h can I get x? It is difficult. Because, there are two variables and you want to get from the want unknown is difficult. So, you need another equation to do that.

(Refer Slide Time: 04:58)



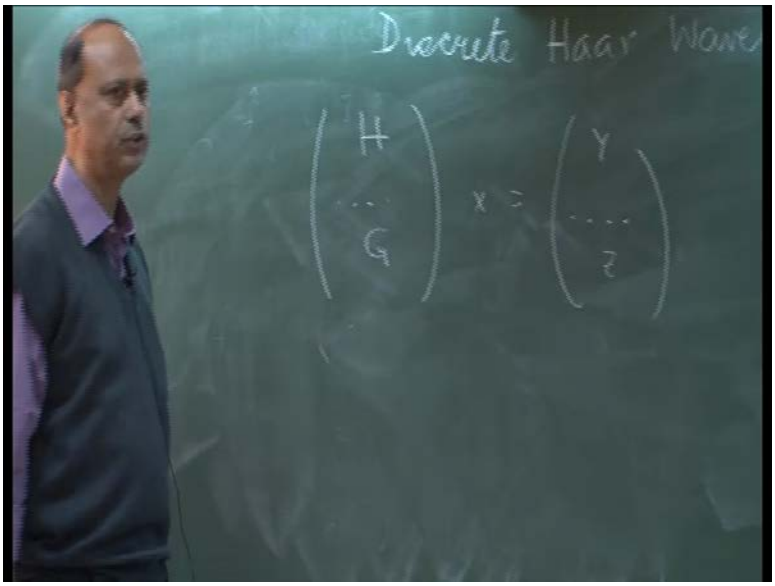
So another equation can be defined. Say, let us assume that z n equals to half of x n minus half of that is a difference or the distance factor. If, I have that y n and z n then you can get x n or x n minus 1, x n is nothing but y n plus z n and x n minus 1 is nothing but y n minus z n. So, basically if I can define or if I have that y n z n then you can get x n or you can define what is x or you can obtain the inverse of whatever result of y you get.

(Refer Slide Time: 05:59)



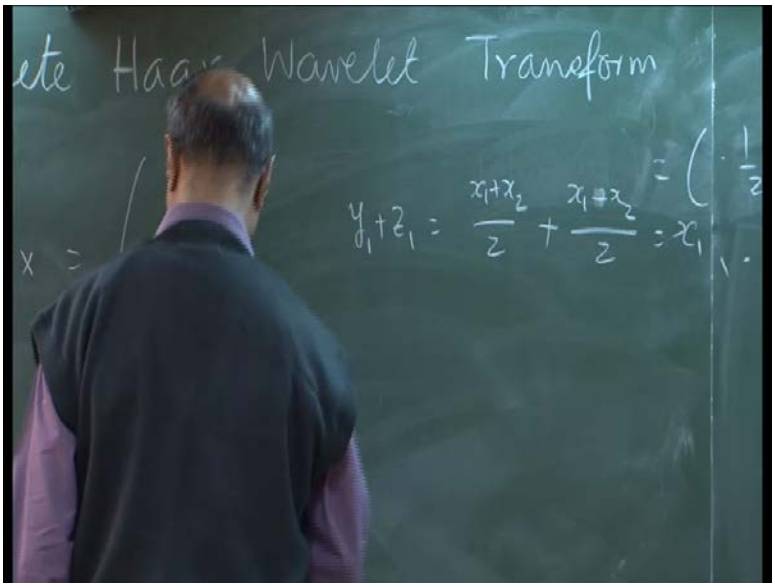
So, if it is there then g can be defined as g also you can easily define, everything is same except here it is minus half half 0. Now, basically what you have?

(Refer Slide Time: 06:26)



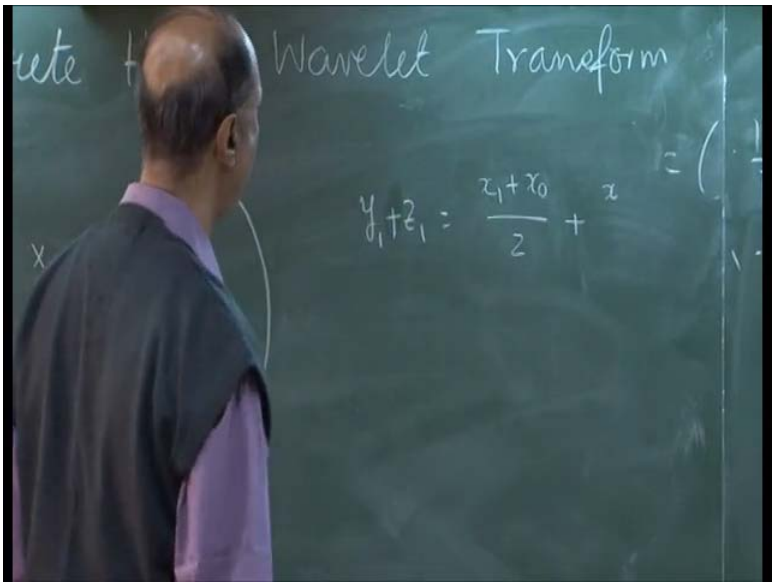
You have your H, you have G, you have X and automatically you get Y and Z. This is given, this is your H this is G and you have X vector and you get Y and Z. So, you can define like this. In some book you will get notation of this type that you have concatenating the two.

(Refer Slide Time: 07:02)



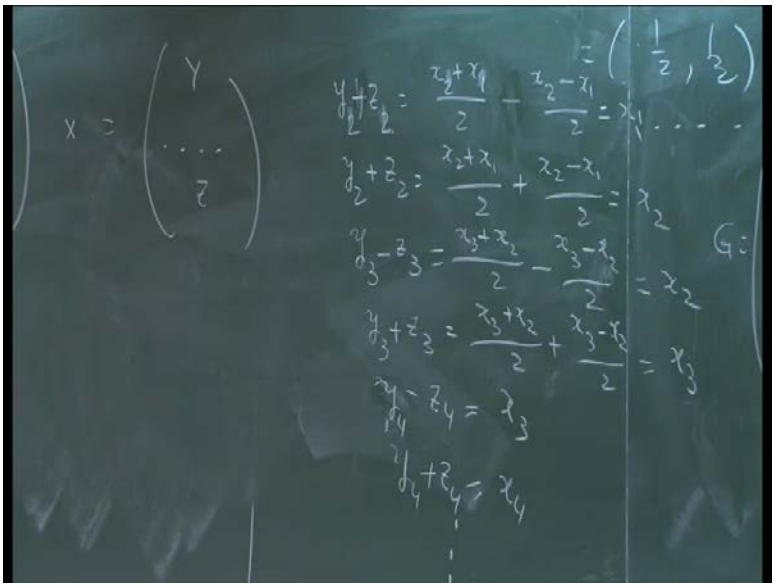
Now, if I expand it you will be getting, that y 1 minus z 1 is your what? y 1is nothing but x 1 plus x 2 divided by 2 minus x 1 plus x 2 divided by 2 which is nothing but x1.

(Refer Slide Time: 07:44)



So first let us take this 1 plus then again x 1 y 1 plus z 1 is x 1 plus x 0 divided by 2 plus but x 0 is not here so I have to write x 2 y 2.

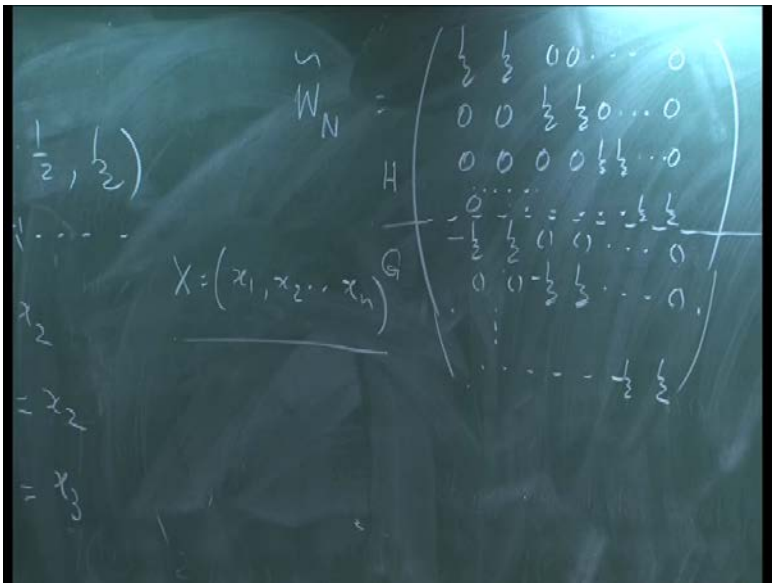
(Refer Slide Time: 08:01)



So, if I have H G into X because y and z then you observe that I can easily obtain, I can easily obtain, what is the value of x 1 x 2 and x 3 and so on.

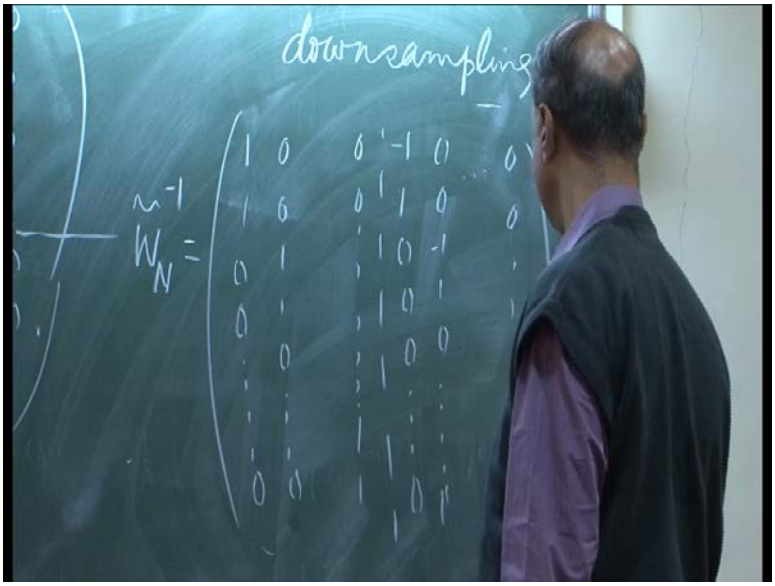
Only thing is that, there is a redundancy if you observe that, from the first row itself, you can obtain x 1 and x 2 again x 2 is obtained from the second row, first row and second row from the second row you will be getting this one. So, it is not necessary or you can get rid of that every alternative row. If you consider one row then next row is not required is it ok? Because so, if I remove this you will be getting x 3 again from here and so on.

(Refer Slide Time: 10:50)



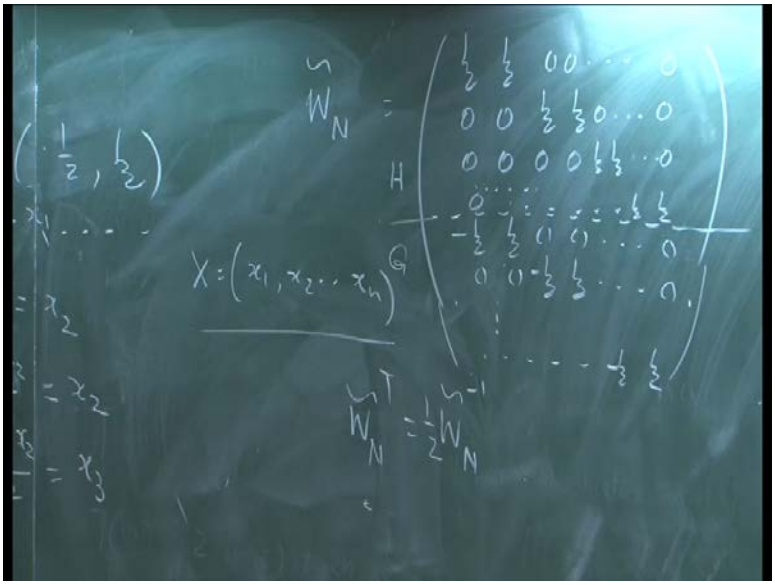
So, you can your that H G matrix as so I have alternatively I am considering so, this is your H component and this is your G component. So, alternatively I have considered the rows, so that what I did? I have I have removed one or every alternative rows to define your W N. For given the X: X is your x 1, x 2, x 3 up to x n. For given X you have defined W N; W N curve by removing alternative rows. And, this is a reduced form of your H G 1 this is known as down sampling.

(Refer Slide Time: 12:30)



Now, if I obtain the inverse of this, because our ultimate target is to obtain the inverse. If I obtain the inverse of it what do you get? The inverse of it will be this is your inverse. So, you get that W N curve in curve value and W N curve inverse.

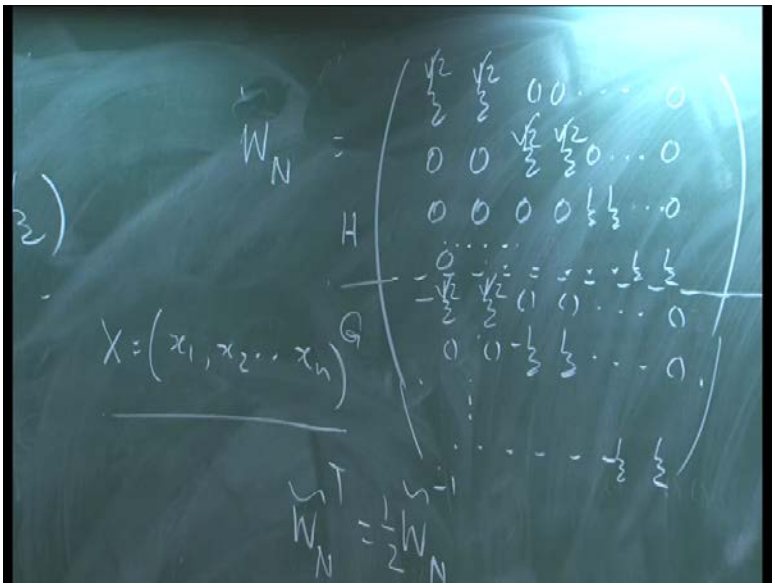
(Refer Slide Time: 13:45)



You observe from these two they are near orthogonal these looks like orthogonal only it will be like this W N. What is the definition of orthogonality? If it is there then you will tell orthogonal but it is not the case here one half is lying.

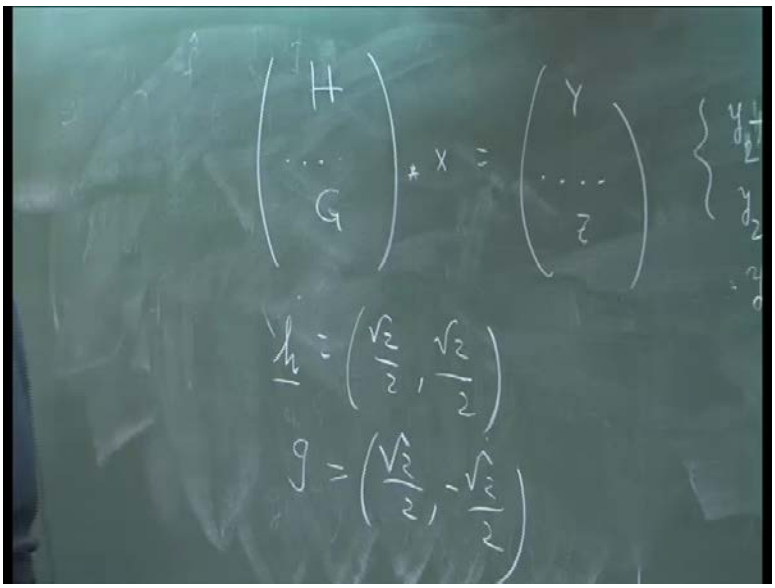
So, you need to do some manipulation. But why I am doing all these things? Because instead of obtaining the directly for me, W N that inverse it is which difficult. What we want to do? We want to obtain the value of X from this W N inverse that is our target. Because it is difficult to get the X from this; X from directly from this, because we want to get here.

(Refer Slide Time: 14:50)



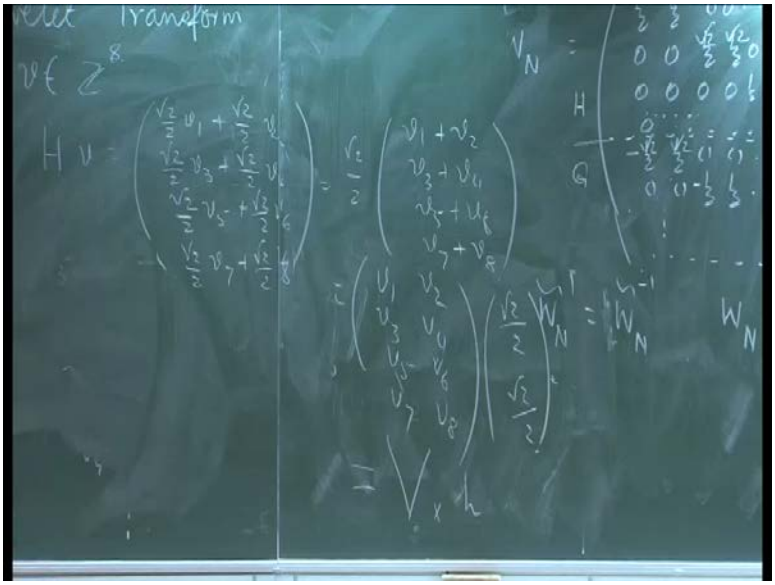
So, I want to get the X from using W N inverse that is my target. Now but half is lying it is not orthogonal to make it orthogonal you just multiply it by root 2. So, here you multiply both sides by root 2 root 2 root 2 root 2 root 2 if you do it then you are defining W N. W N is defined by multiply the root 2 to every element in that case you will find they are orthogonal. So, W N is equals to W N inverse.

(Refer Slide Time: 15:14)



So, in that process your h becomes h becomes not half by half and half it is root 2 by 2 root 2 by 2 and your similar definition for g is root 2 by 2 minus root 2 by 2, because I have multiplied by root 2.

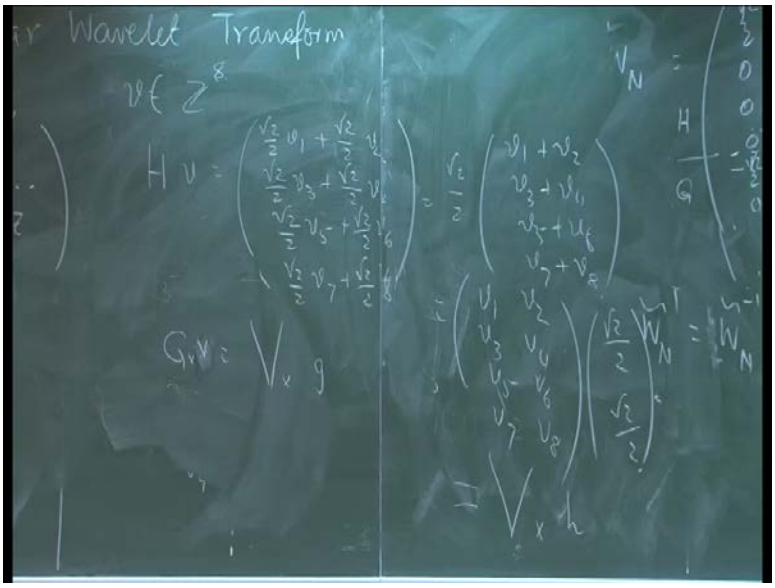
(Refer Slide Time: 15:51)



Suppose, there are eight variables v 1, v 2, v 3, v 8, now you have H v and so basically if you see this is your h component. If I think about H v then you will be getting root 2 by 2 v 1, plus root 2 by 2 v 2, root 2 by 2 v 3, plus root 2 by 2 v 4 is it ok?

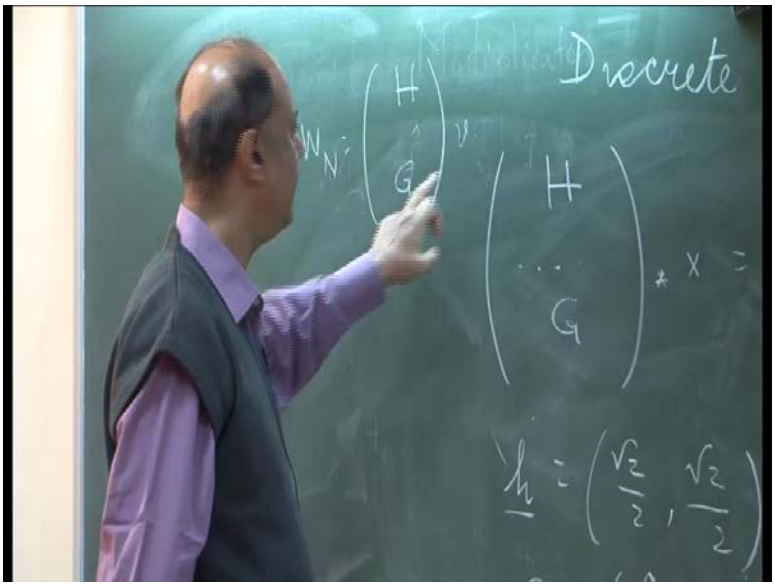
So this is nothing but and this I can write v 1, v 2, v 3 in the matrix form. And this gives you basically a matrix V into into your h. This is the h you defined; this is h that V is 4 cos 2.

(Refer Slide Time: 17:52)



Similarly, you can define G v as vector V. Actually, this should be v basically this should be v vector V into g. This is matrix V and this is v 1, v 2, v 3, v v 8.

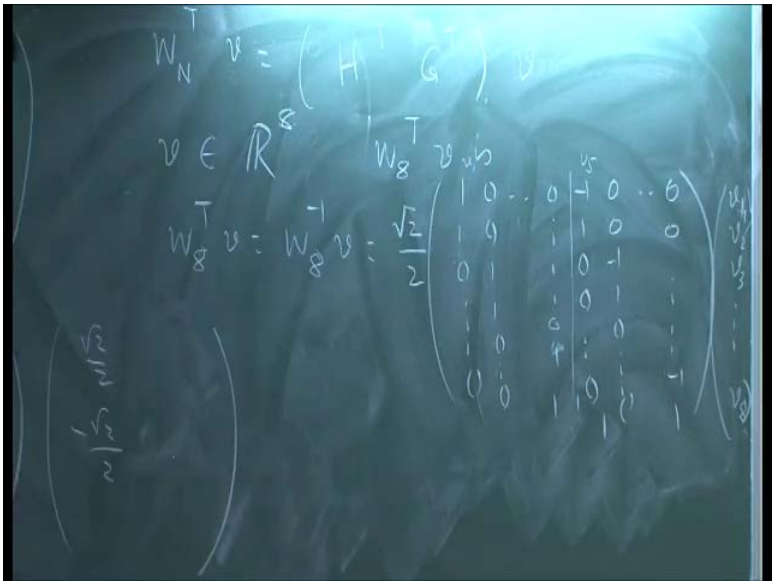
(Refer Slide Time: 18:23)



So, you have W N is your H component and you have G component and you have v. That is your W N H G and your v that means you need H v and G v. So, to compute H v and G v you just compute v and first you compute v and then you multiply with g and also compute (Refer Slide Time: 17:52) V multiplied with h you will be getting your W N.

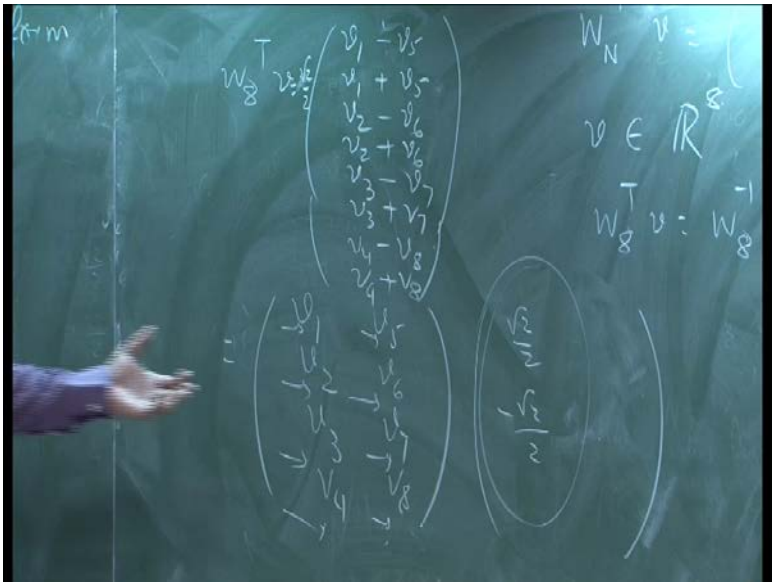
So, H v will be replaced by your V h and G v will be replaced by V g.

(Refer Slide Time: 19:13)



Now, actually to obtain that inverse you have to do little tricky way W N T v is nothing but your H T G T v. Now, consider our v belongs to let us say R 8 as you have considered earlier. W 8 T v becomes W 8 T v is equal to W 8 inverse v and this is orthogonal. So, I am writing and your v is v 1, v 2, v 8, v 1, v 2, v 3, v 8.

(Refer Slide Time: 20:47)

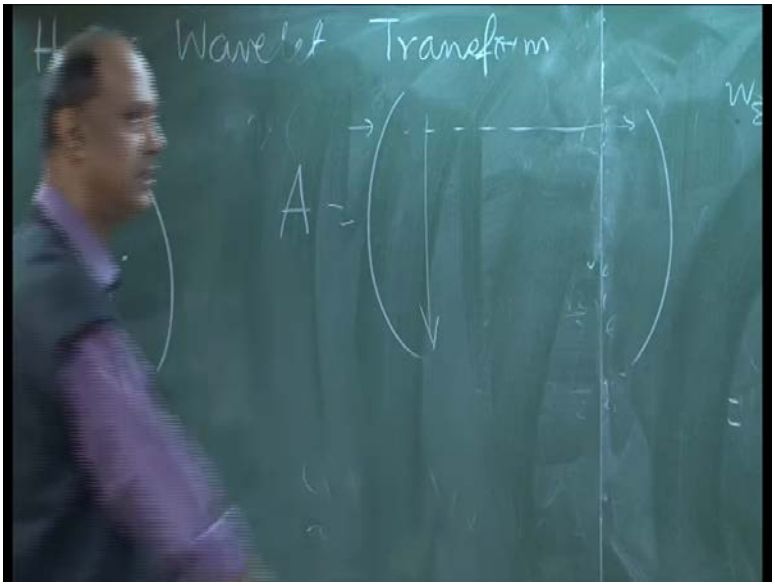


So, you get W 8 T v is nothing but of course, root 2 by 2 is here, v 1 minus v 5 v 2 plus v 6 this is v 1 plus v5. So, this can be written as v 1 v 5, v 2 v 6, v 3 v 7, v 4 v 8. This

multiplication is correct v 1 v 5, this goes this is ok? So, that is also correct, but how to get from here from to here. First row is getting this with this I got this one I have to get 8 cross 1 row. This into this; this I will get next one is I have to repeat this basically here I have to repeat that means v 1 v 5 minus v 5 like that I have to write so, you write this.

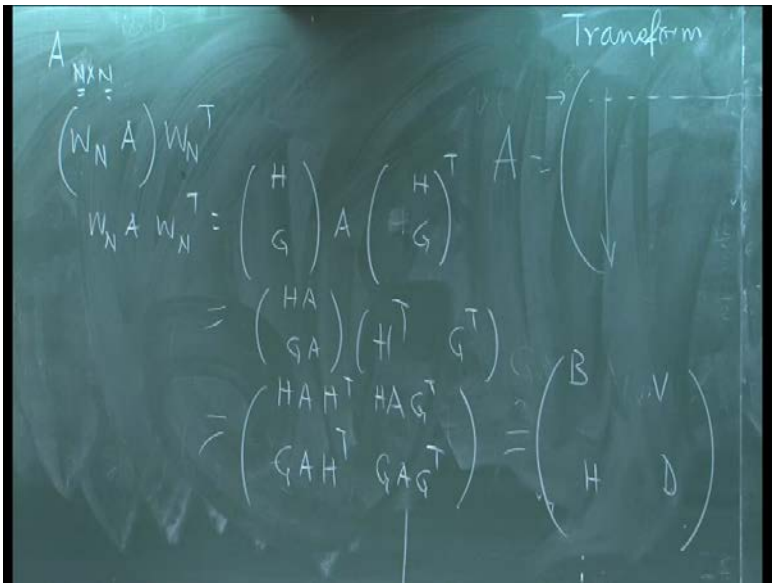
So, if I can manage now you are see you observed that you got this component is known to you and variable v 1, v 2, v 3, v 4 is there so, vector v is so matrix v also you can define. So, once I know this I am I am ready to obtain now that I got now inverse because this is I have written in terms of that now you can easily find out what is your x 1, x 2, x 3, x n. Now, this is basically you will be getting one dimensional, because I started with the one dimensional array vector V.

(Refer Slide Time: 24:31)



Now, what happens if I have the two dimensional array? You have an array A you have the two dimensional array. Now, if you consider that one dimensional array row column wise this direction, no column wise vector is this direction, if I use this direction then, whatever adjustment you are doing that will be column wise but adjustment is required for two dimensional so row wise also.

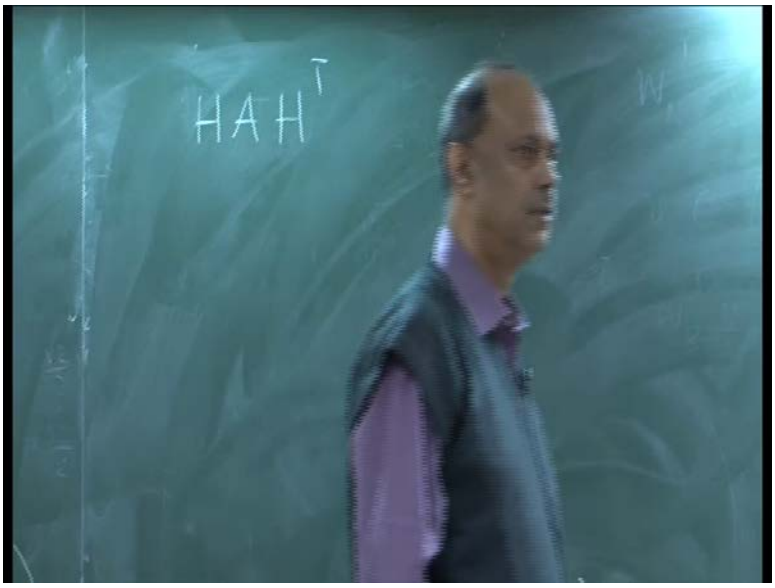
(Refer Slide Time: 25:17)



So, in order to make the transform on A to transform on A so, A is your n cross n image here you are assuming because every alternative row is coming in this picture so N is even. So, to make the transformation, first I will be making W N A. That will give you the column wise transformations. Now, in order to get the row wise transformation you just put W N T. That means, first you will be computing W N A and then that one and then you will be multiplying by W N T. So, that will give you the both side row wise and column wise transformation.

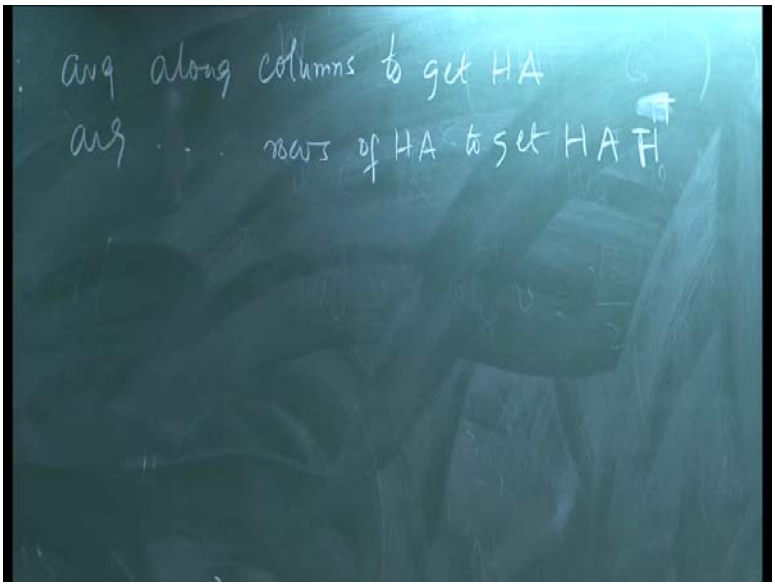
Now, if I want to write it mathematically W N T A W N T what is W N? W N is nothing but you have H G you have A and W N T is nothing but H G transform. This is nothing but H A G A H transform G transform this is nothing but H A, H T, H A, G T, G A, H T and G A, G T and this is termed as B, V, H, D. B is basically actually we used to term approximate but I have used a there so I am writing B; B is also you can use a blur and V is vertical, H is horizontal and D is diagonal.

(Refer Slide Time: 27:54)



What it means H A H T? Basically you are making the average you are making the average along the columns.

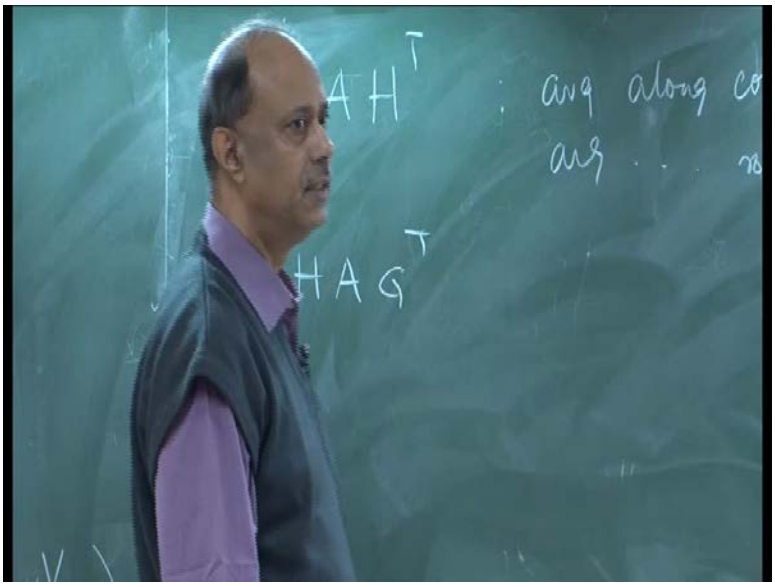
(Refer Slide Time: 28:14)



And after that again you first average along the column along the columns to get H A then again average along the rows on rows of H A to get H A T, H A H T. That is to get the blur. First you average along the columns, then you average along the rows to get the average of average basically. And, that will since you are doing the average of average basically what you will be getting? You will be getting a blur image.

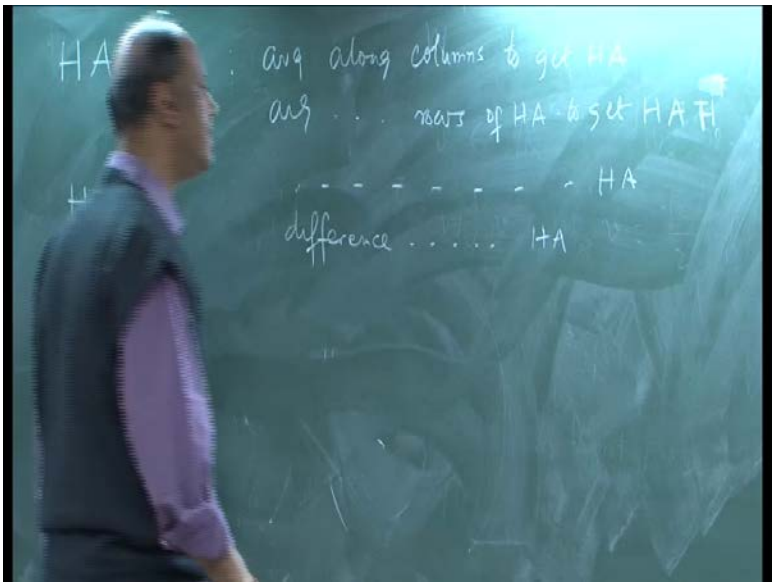
Or, it is known also as approximate image. One thing you remember in that process you are reducing the size by one forth, half of the average towards this direction average towards this direction of the two consecutive numbers so size will be reduced by this side half and this side half so size will be reduced by one fourth reduced to one fourth.

(Refer Slide Time: 29:29)



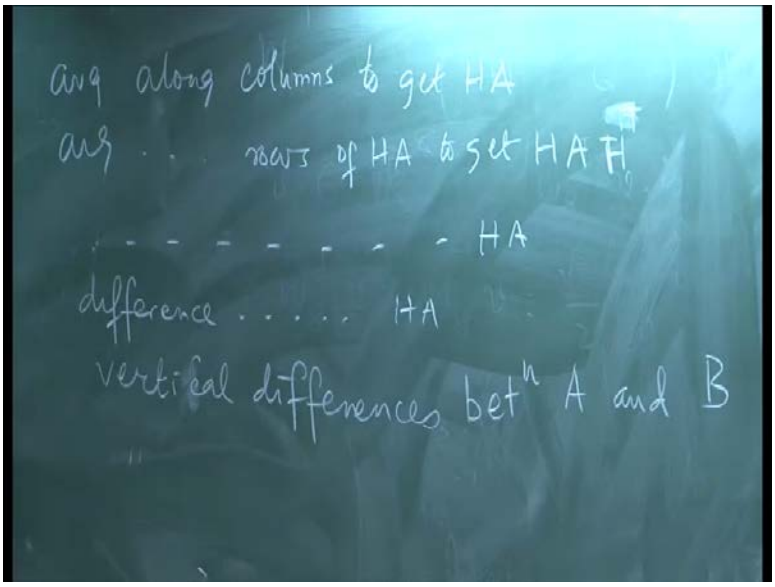
Now, H A G so here you first observe that I have done H A operation first then G; G is nothing but the difference. You remember the difference is half and this side also a minus half.

(Refer Slide Time: 29:49)



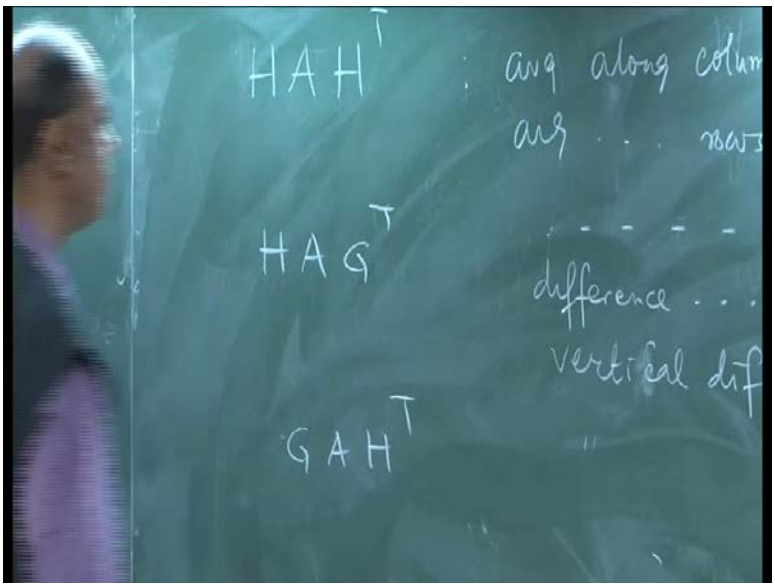
So, average along the columns to get H A; then you obtain the differences along the rows of H A to get H A G T.

(Refer Slide Time: 30:16)



And this will give you vertical difference. This will give you the vertical differences between A and the blur image B, H A G T first it is giving you the average along the columns to get H A then difference along the rows of H A to get H A G T and this will correspond to the vertical difference between the blur image and the original image.

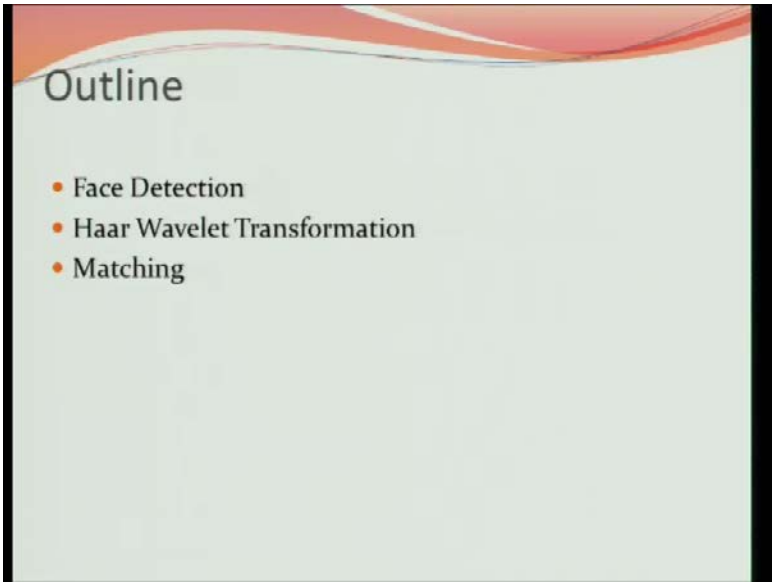
(Refer Slide Time: 31:08)



Then, it is coming G A H T so this is nothing but first you obtain the difference and along the columns to get G A and then you obtain the average along the rows to get along the rows of G A to get G A H T. First you obtain the difference, then you obtain the average along the rows of G A to get G A, H T and this will give you horizontal difference between A and B this will give you horizontal difference between A and B.

The fourth one is G A, G T that is first you obtain the difference along the row columns to obtain G A. Then, the difference of rows along of G A and that will give you the G A, G T and this will be giving you the diagonal difference between A and B. (Refer Slide Time: 25:17) So this this this will be used for our feature extraction algorithms. And, this is known as Discrete Haar Wavelet Transformations.

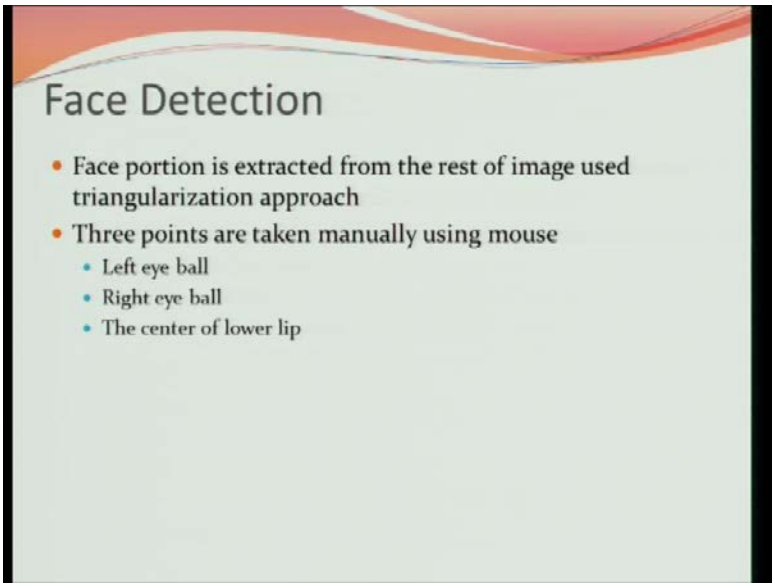
(Refer Slide Time: 32:39)



Now, we are ready to explain how to use the Haar Wavelet, today I will be covering only face that means the oval shaped face we have to get it. Once you get the oval shaped face because I do not need here I do not need t shirt and other thing I only need this oval shape and then you will be performing the Haar Wavelet Transformation on it.

And, from the Haar Wavelet Transformation you will be getting the feature vectors and that feature vectors you will be using for your matching purpose, for your decision purpose.

(Refer Slide Time: 33:17)



Now, how to get your face? How to detect the face? Now how to detect the face? It is oval almost oval, this is nobody can argue on it some of them may have the triangular tilted one but it is oval. Now, to get the oval shape I need the 3 points to define my oval. So, the simple way is that, generally it is may observed that the eye(s) black portion they maintain the equal distance from the nose tip, the black eye part black part of your eye from the nose tip they maintain the same distance.

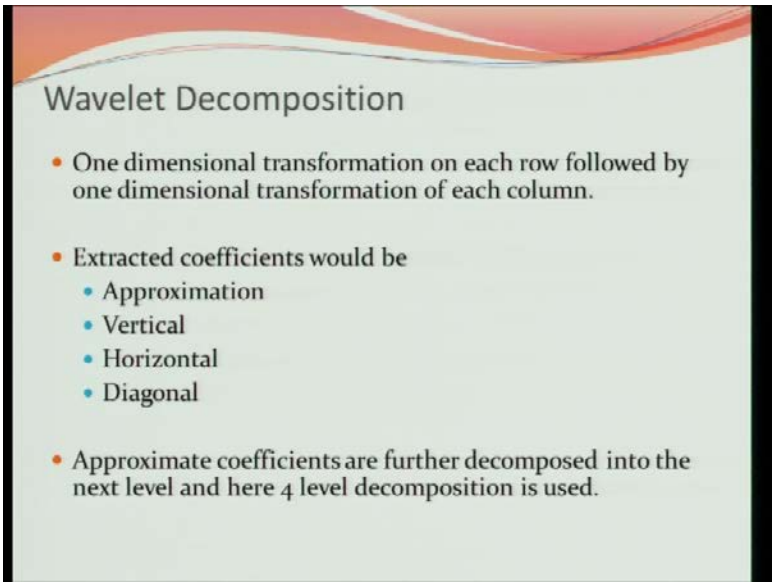
And also the distance from the eye ball to your center of the lip is also maintaining fixed distance. Because, it is almost symmetric so from this point and this point this distance and this distance generally they maintained fixed and topometrically it has been showed. So, if I know these 3 points I can obtain the centroid of that and from there I can obtain the oval. I can draw the oval. Now, oval drawing even though I tell it is very simple but it is not that simple because the face size may be variable the size of the face is variable.

So, what do we do? First, we normalize the image so that everybody(s) face size is fixed, now you can draw the oval. So, once oval is drawn, you can crop the image only retain that oval for your work.

(Refer Slide Time: 35:15)

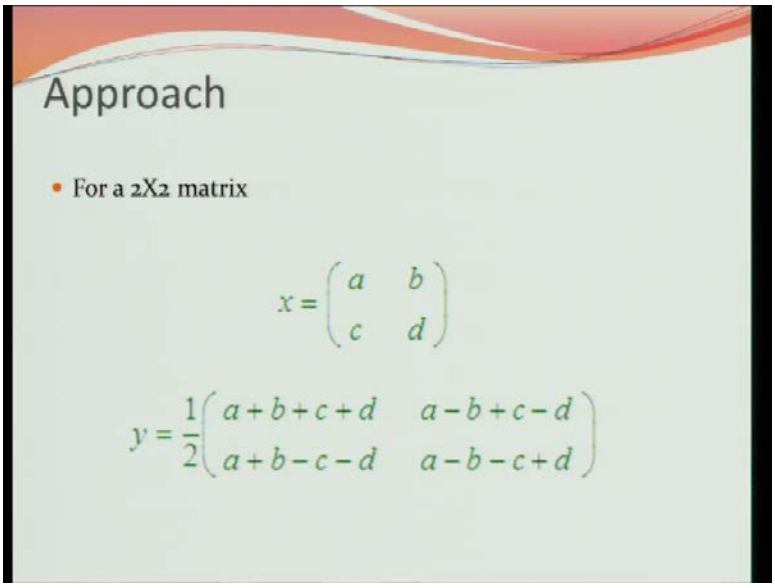
So, that is your face detection. So, this is an example so you got the centre of this this and you have drawn the oval and you got the cropped image.

(Refer Slide Time: 35:28)



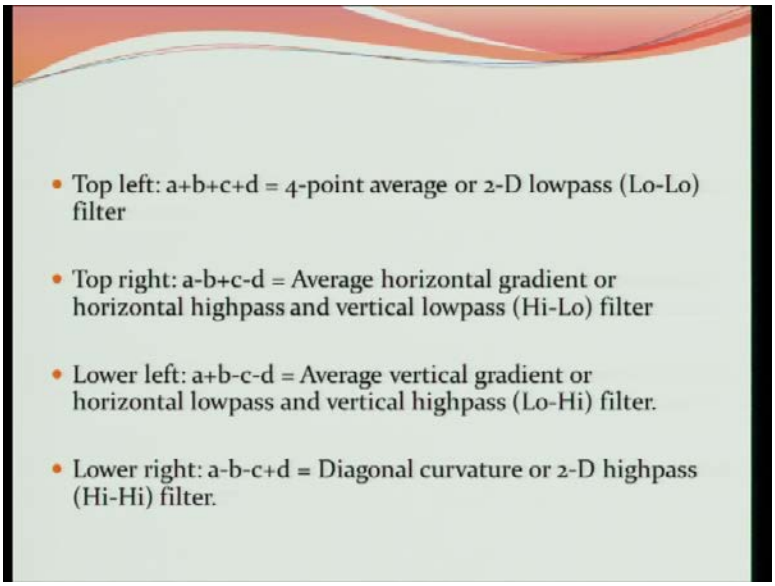
Now what we have done here the Haar Wavelet Transformation.

(Refer Slide Time: 35:33)



First, one-dimensional transformation on each row, followed by one dimensional transformation on each column.

(Refer Slide Time: 35:39)



So, row wise I have done because in my discussion it was column first then row (Refer Slide Time: 35:28) here I am doing the row wise first it does not mean anything there is no difference only thing the vertical and horizontal will be interchanged, position of the vertical and horizontal will be interchanged nothing more than that.

So, what we get? If I do the transformation first with respect to the row, and then with respect to the column, you will be getting the two dimensional transformations and you will be getting the blur image, vertical image, horizontal image and diagonal image but the size will be reduced by one fourth. Now, if I reduce the second level, I consider only the approximation image and again, I perform the Haar Transformation size will be reduced again by one fourth.

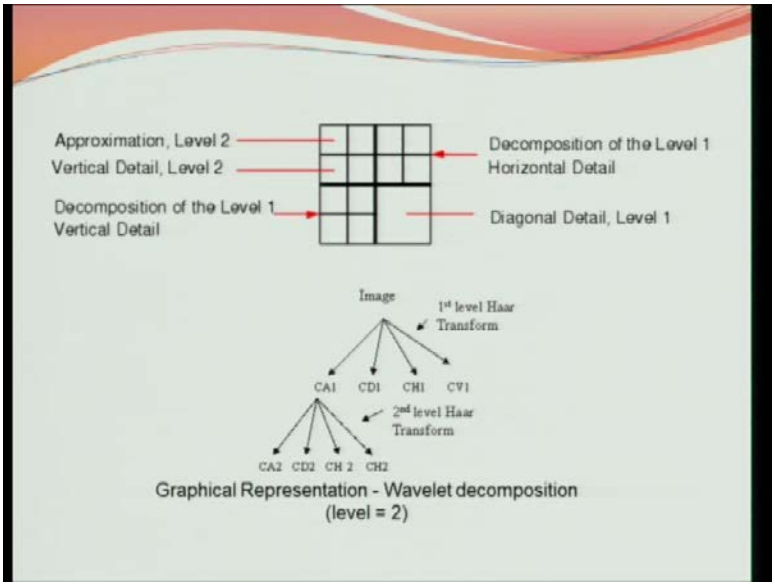
That means, the two level transformation if I do then, size will be reduced to 1 by 16. 3 levels again 1 by 4 so 4 to the power 3 and then 4 levels transformation means 4 to the power 4 the size of the image will be reduced by 1 by 4 to the power 4.

(Refer Slide Time: 35:33) So, let us consider because for display purpose I I have considered only the 2 level transformations. Let us see how it looks. Say you have the 2 cross 2 matrix x equal to a b c d these are the 4 gray values or four image values. Then, what will be approximation value as I told you this is a average of the first you take the average and then you take the and then sum average will be there here.

And similarly, a minus b plus this is actually horizontal thing first difference and then average and here it is the average and then difference and this is here difference and difference. So, that is the thing we covered there. This is the B component this is your V component this is your H component and this is your diagonal component this is just interchanged one. First, I have taken the average here it is the difference and then average, here it is the average and then difference and here it is difference and difference.

(Refer Slide Time: 35:39) So, the top one is basically average of average, it is known as the low pass Lo Lo that is if you think about the filtering algorithm so, this is a low pass filter twice and here it is average of the horizontal gradient or horizontal high pass. So, it is a vertical low pass so it is the Hi-Lo and then next one is Lo-Hi and finally, Hi-Hi high pass and then high pass where different operators you have used twice.

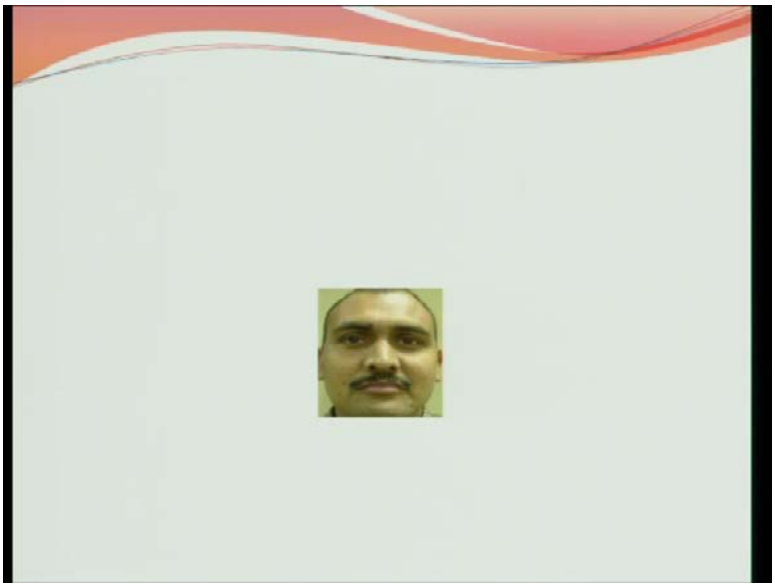
(Refer Slide Time: 38:39)



So, if you think about that diagometrically, you have the whole image and you have the one level transform once you do it this will give you the approximate component, this will give you the horizontal component, this will give you the vertical component, this will give you the diagonal component.

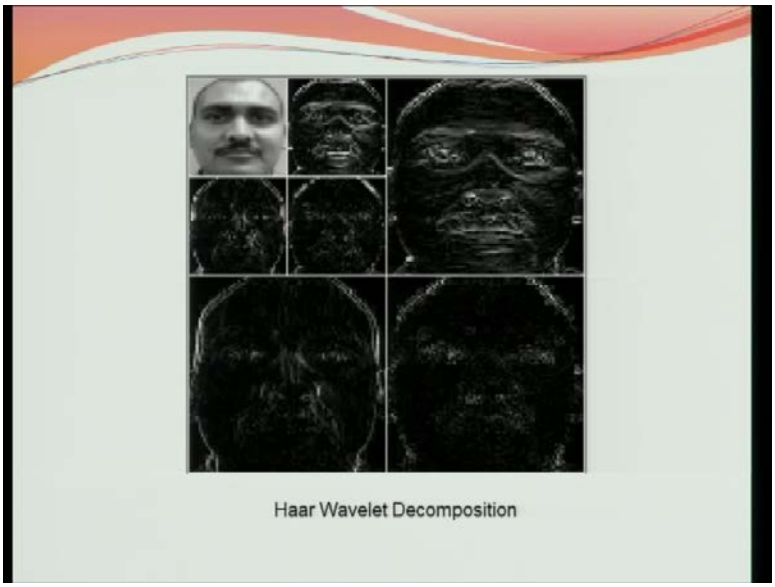
Now, again if I perform the Haar Wavelet here this will give you the approximate, this will give you the horizontal, this is the vertical and this is diagonal component. So similarly, we have done it for 4 levels.

(Refer Slide Time: 39:19)



Now if you see the image, this is our original image.

(Refer Slide Time: 39:21)

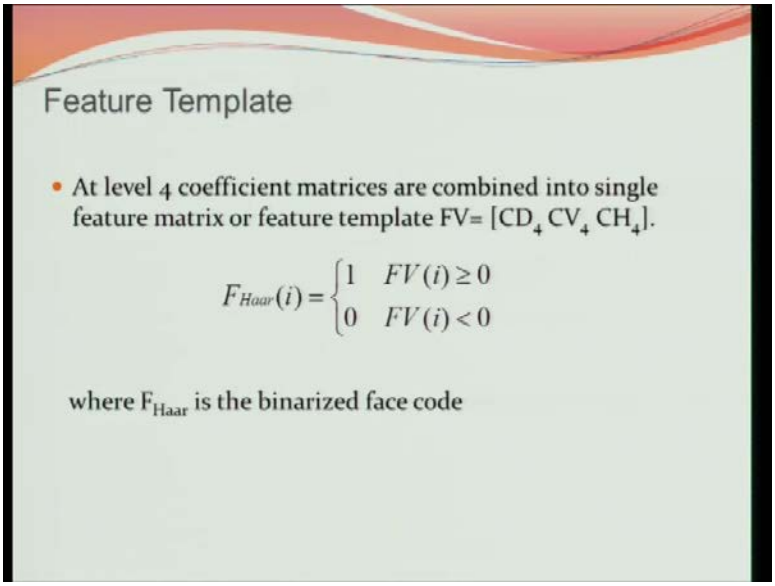


Now this this is your horizontal changes, horizontal difference, this is the vertical differences, this is the diagonal differences and here it was an approximate approximate is the blur image. Image will be the same as looking for. So, same thing again on this; this is your horizontal, vertical and this is diagonal. Now, these are the things if you do the 4 levels you will be getting another level another level so on.

Now, you observe that which component I should use for my feature? Where is the feature here? Which one I should consider? What is the definition of horizontal? That whatever changes you have horizontally, that will be considering that is the unique property of your face. What is the vertical changes you have? That will be the unique property towards your vertical image vertical difference and this is for the diagonal defects.

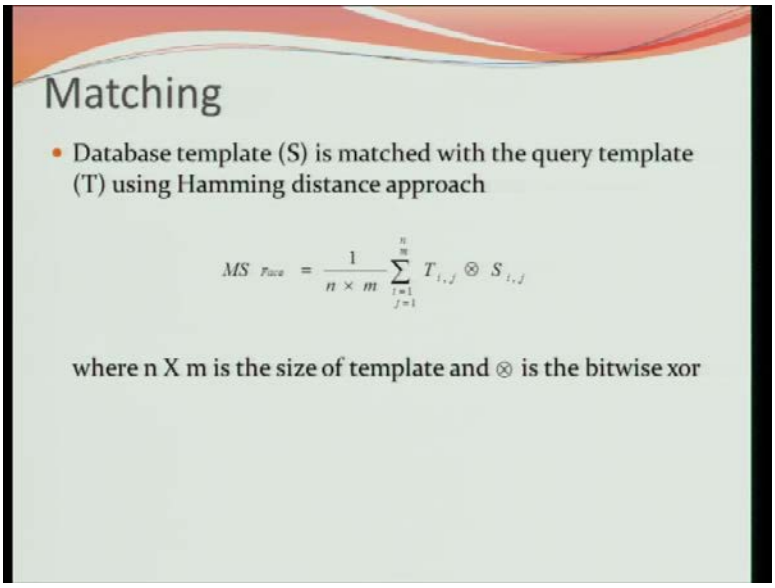
So, instead of having using this one that this is the blurred image and this image may be there is not much thing involved in that but these two are these three components are giving you the features. Now, these feature points these value these gray values you will find that some of them are positive and some of them are negative.

(Refer Slide Time: 41:04)



Because you have used in some case difference and some case addition; so, there is a possibility some of them are negative and some of them are positive. Agreed? Those are positive values you put 1 those which are negative you put 0. So, you have the diagonal component vertical component and horizontal components of level four, others I have ignored.

(Refer Slide Time: 41:218)



And (Refer Slide Time: 41:05) then I have put the feature I have defined the feature factor where element is 1 if this value is non-negative and negative if then it is 0. So you get a bit vector, of what size? 3 into the image size divided by 4 to the power 4 am I right? So that is the size; size is not very big very small size. If you consider the image size is 512 cross 512 so, this size is reduced to first level 1 by 4, second level 1 by 16, third level 1 by 64 fourth level is 1 by 256. So, it is coming half cross half. So, 3 into 4 that means 12 feature vector will be 12, that is not big and it is a bit vector am I right? So, size can be controlled based on your need. So, bit vector operations you have to do.

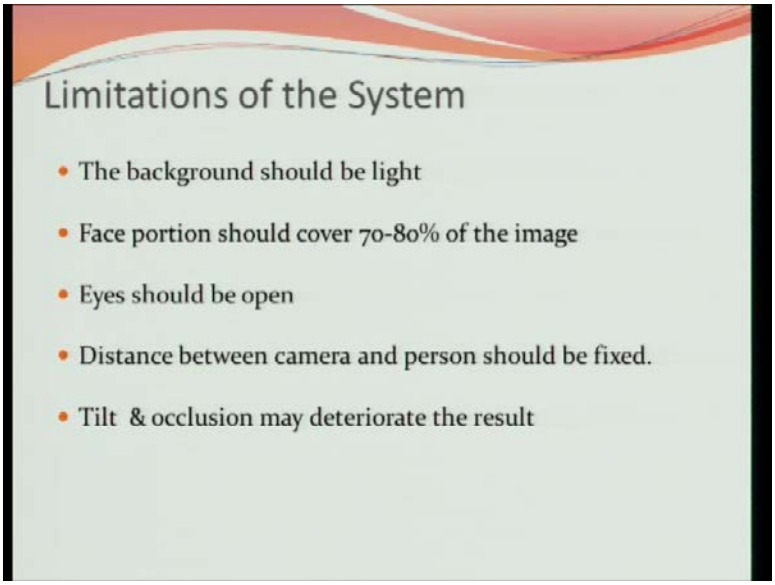
Now, you get a feature vector. Which is a bit vector and which got this either 0 or 1. Now, if you have the another bit vector you have to because all of them are normalized size will be same, only it is assumed the face is the (( )) face and you have extracted your face based on some formula, so it is also fixed size it is taking the frontal face, bit vector I have considered. So, if I by any means I can obtain the bit vector difference and then number of one(s) match number of zeroes match that will give me my score matching score am I right? So, that is known as hamming distance; hamming distance is nothing but xor operation between the two divided by the size of the image n cross m.

So, that will give you the number of one(s) matched number of zeroes matched and that will be your matching score. Agreed? Now, these matching scores are used to determine whether he is accepted or not. Suppose, you have a person is there, there is database of

size n and this person(s) feature vector will be xor with everyone(s) and then you will be getting the matching scores. And, in the testing case you know he is not a genuine person. So, you can fix a threshold if it is more than that you accept, if it is less than that you reject and you can obtain the false acceptance rate and false rejection rate.

I think the false how to compute the false acceptance rate and false rejection rate? I have discussed in earlier. So, you can easily obtain.

(Refer Slide Time: 44:42)



What are the limitations we have? One limitation we have put in our case that, background should be light. Why background should be light? Because otherwise the reflectance property light reflectance properties coming in between and the face values will be different, that is one observation what we have seen. Then, what we observe? Their face coverage should be 70 to 80 percent of your detected face. Because, that means once you round shaped is that there will be some part which is outside of your face. So, we can ignore.

So 70 to 80 percent coverage should be there. We need to see the face is open, eyes are open; why eyes are open? If eyes are not open then you will not be getting the black part and once black part is not known you will not be able to draw the oval. So, black eye eye should be open which is the difficult problem, because you cannot expect that everybody(s) eyes are open. There are people you will find that, they are not friendly in front of a camera they close their eyes or if it is a dead body the eyes are closed.

So, you will not be able to detect the face. So, eyes should be open that is the constant which is also one should think how to get rid of it. Then, we are telling the distance between the camera and the person should be fixed, why it is so? That I get the normalized image, I get the fixed image. Otherwise what happens? One image will be very small another image will be very large and once you reduce the image size or you extrapolate the image, there is a possibility that you are introducing the error or you are you are suppressing some feature points. So, that is the reason why we are expecting that the distance between the camera should be fixed, which is also another difficult or very difficult issues.

Because one cannot expect that my camera distance from the subject should be fixed always this is not feasible. And the Tilden occlusion may deteriorate the result. There are people sometimes they tilt their face, there is a pose gets changed. Then expression may be changed and also that there may be they put some occlusion here and there and that also may create the problem. So, these are the certain limitation what we observed on Harr based algorithms.

Accuracy what we we have very small database size. Accuracy also we have observed that it is 80 between 84 and 88. But achieving more than 90 percent accuracy is difficult in the case of face. I think that is all about your face biometrics, any questions?

(( ))

Large for identification purpose what does it mean? Reason is that if you have the large database then the feature vector is small. But issue is coming that what I am getting? In that case, that 4 level compression will not work. You have to reduce that compression level say 2 level compression then 2 level compression size is increasing.

So, there is comprise between because you know every face has some common part with every other(s) face. So, there is a possibility that number of one(s) matching score would be more. So, you have to be very careful for that and that you can see from twin(s) case from the twin brother case we will find that Harr will not be successful model.