Biometrics

Prof. Phalguni Gupta

Department of Computer Science and Engineering

Indian Institute of Technology, Kanpur

Lecture No. # 19

So, today first I will be starting with fingerprint then, if time permits, then I will cover ear biometrics; and after that your quiz will be there. Now, so what are the advantages on your fingerprint?

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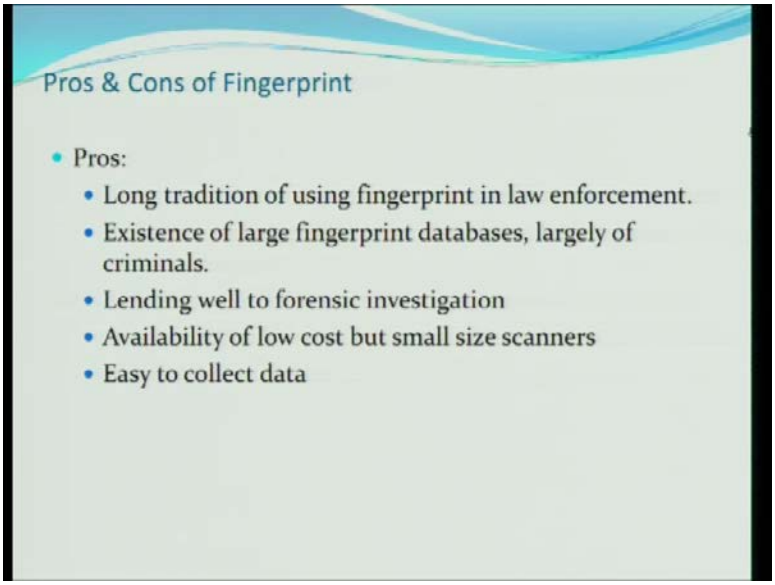

First one is the long tradition of using fingerprint in law and enforcement; that is in police case, you will find that they have taken the fingerprints, they collect the fingerprints. You go to registration area land record, where you have given the fingerprints.

The next one is the existence of large fingerprint database, this is also important thing, because if you have the large database, then you can test you can test your system to find out what is your f a r and f r r, am I right? Because that is the most important thing that what we do otherwise, what I do otherwise that if I have the small database say thousand size then f a r (( )) finding f a r is basically obtain to the power 3 into 2 that is 6 size.

Whereas, competition you have only the 1000 database size. But in the case of fingerprint it is the large fingerprint database you have but mostly from the criminal area. Then, it is being used very much for quite some time that on forensic investigations. The scanner cost is very small, very less, very easily available and size is also very small, you can take it from one corner to another corner easily. And it is easy to collect the data you can tell anybody that put your finger on the top of it, and then you can get the data immediately.

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But it has several disadvantages; first one is that it has poor public reputations. What it means? That it is related with the criminal. So, whatever database we have that it is related with the criminal and then you feel bad to make the study with the criminal data that you are handling. So, you may not like so, it has a poor i d things, and then you have the social stigma that most of us we know how to sign.

Now, if you tell that give your fingerprint the society feels social stigma means the society feels that why shall I, I know how to sign and why shall I give my fingerprint? So I am an educated person I know how to sign I do not like to give my fingerprints. There are people they feel that by giving fingerprints I may lose lot of money, something like that that fingerprint is very you know I can sign on the blank paper but I do not want to give my fingerprint on the plain paper. So, that type of stigma exist then, large variation of the quality of fingerprints over the population. It depends on age. (Refer Slide Time:

02:15) Then there are people, they put oily food on their hand and then if you give the fingerprint then it gives something the data gets smudged. And, it gives you the different types of fingerprints.

Then there may be cut on the fingerprint. And so it depends on the occupational lifestyle also. Now, how do you give the data? Data you will be giving on a scanner you will be putting the fingerprint or finger on the scanner and then depending upon the environment you have to give the pressure on the scanner and then the data will be collected. So, how you are giving? How much pressure you are giving? What angle you are putting? All those will be coming in between.

So, that is the reason you see there is a problem you will find that the way you press the finger on the scanner to provide data, that is there it exists. And also, there is a problem of cleanliness of the sensor, because if the sensor is not clean then lot many noise may be there; that noise may create the extra minutiae points.

And also the word of public hygiene; public hygiene means that suppose, I put potassium cyanide on my finger and I give the pressure and then I leave the place. Then the potassium cyanide powder will be on the top of the scanner, the next person will be putting his finger and there is a possibility of havoc or creating the problems in the society. Next one is the non availability of the fingerprints. There are 15 percent of the people in India itself you will find that they do not have the fingerprints the finger exists but fingerprints does not exist, because of their hard work and work style. Finally, there are people they may not have the finger. Suppose, I consider that ring finger is your finger from which you will be giving the data and concerned person may not have the ring finger and so on. So, there are several disadvantages.

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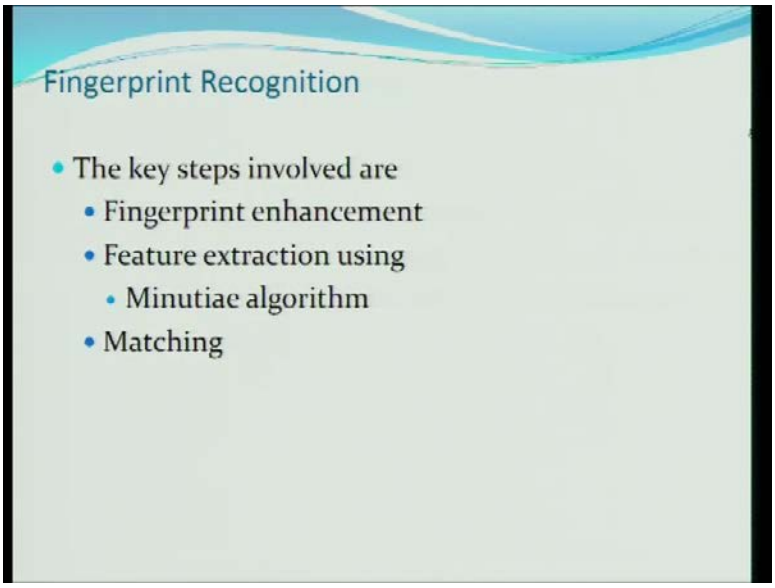

Now, like any other biometric system in the case of fingerprint you have the following steps. First one is that you have to enhance the image. And enhance from the enhanced image you will be extracting the features these features are the minutiae points, because our algorithm is based on the minutiae points and finally, matching.

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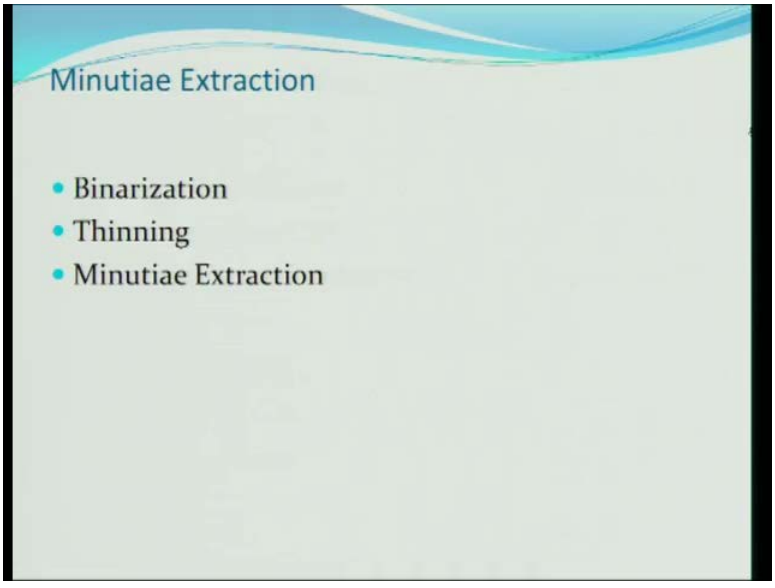

What are the enhancement techniques? You have given the fingerprint image that is you have to convert it to the grayscale image, you have to convert it into the binary image

and then you have to thin it. So, you get here thin means, what? One pixel edge and then you have to extract the minutiae.

How to Binarize? That is known to you. How you are going to do it tell me? One method threshold you get a one threshold and then above some threshold or first you obtain the histogram and see that is there any pic based that on you decide this one this part will be considered as the 0 and other part will be considered as 255.

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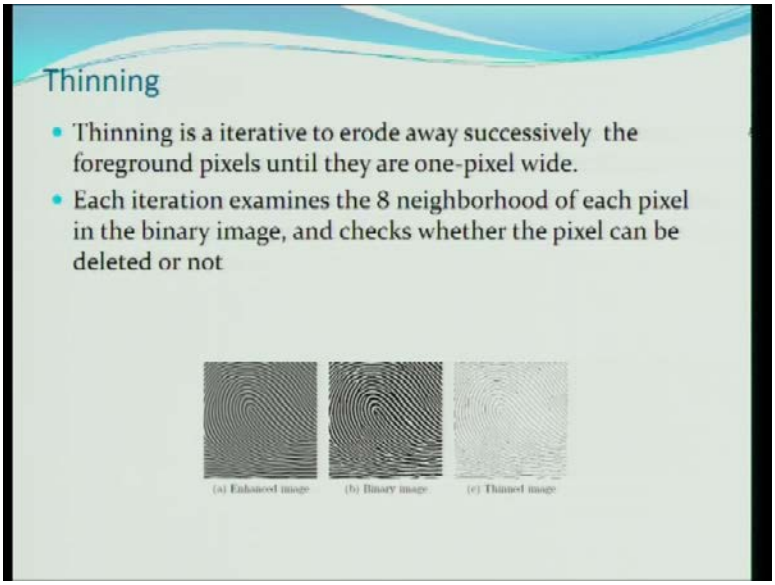

Now, once you get the binary image you will find that edges will be thick thick enough edges will be thick enough this is the binary image and edges will be thick enough. Now, this thickness is not constant, this is variable. But that will not help us we need to make it constant with edges so thinning is required.

How to obtain the thinning? It is an iterative process, because in one step you will not get it. So, you make a mask say 3 cross 3 mask and that mask you will be putting you will be covering from one corner to another corner row wise and if you get all one(s) then you put the centre is one other like that or several one(s) you put the central one corner diagonal ones then you put the centre one and so on.

So, after certain stage you will find that there is no one replacement is coming. And, so you will tell that that the thin image you have obtained. Now, agreed is it clear? So, you got the thin image. Now, if you look at the thin image, there are several characteristics. I

do not know whether you can see it or not here there is a point from where, there are two edges are coming. These edges are known as ridge. These are ridge and inside thing is the valley.

Here you can see that, it has stopped here. So ridge divided this is known as end point and this is bifurcation. In a fingerprint you will find that there is a possibility of bifurcation. But trifurcation will not be there. Either ridge will be stopped at some point this is known as ridge ending or you may find that it is continuous line. So, it is a continuous ridge point or you can find that ridge is a bifurcated one.

So, these ridge ending points or this point these are bifurcated, they are considered as the minutiae points. Now, these points are represented by 3 factors; one is x coordinate another one is y coordinate and another one is the direction or angle. What angle it is coming? This or but if you move it whether it is what angle it is creating, that angle.

Now, also we have another parameter, which is known as type parameter whether it is a bifurcation or end point. We will be considering one of the two minutiae point is either of the type of end point or the bifurcation and it is at the coordinate x and y along with theta degree.

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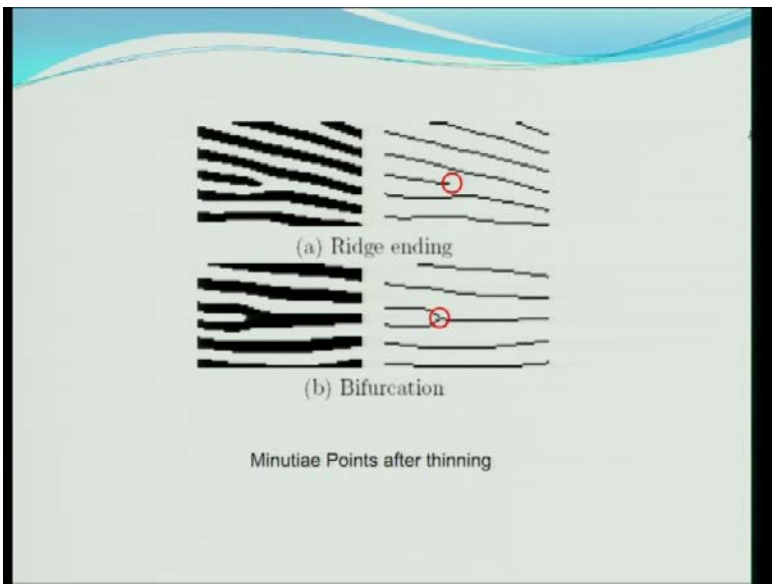

So, this is an end point ridge ending and this is the bifurcation point

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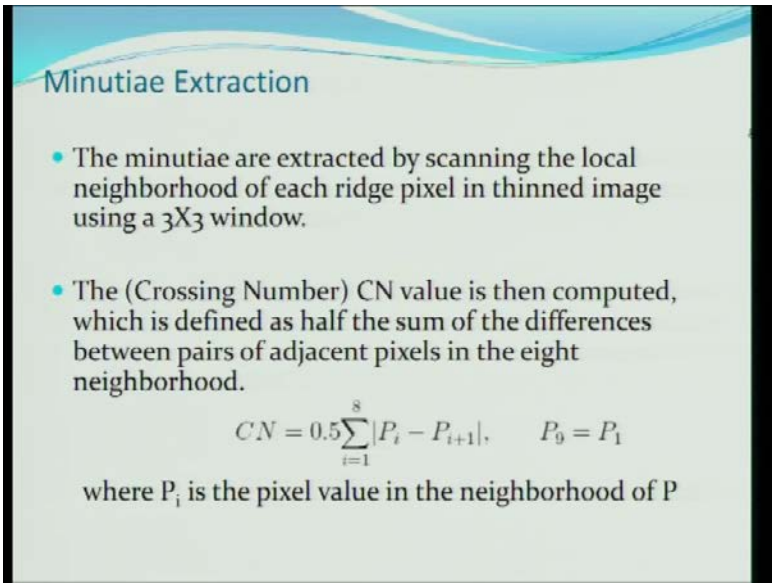

Now how to extract the minutiae points?

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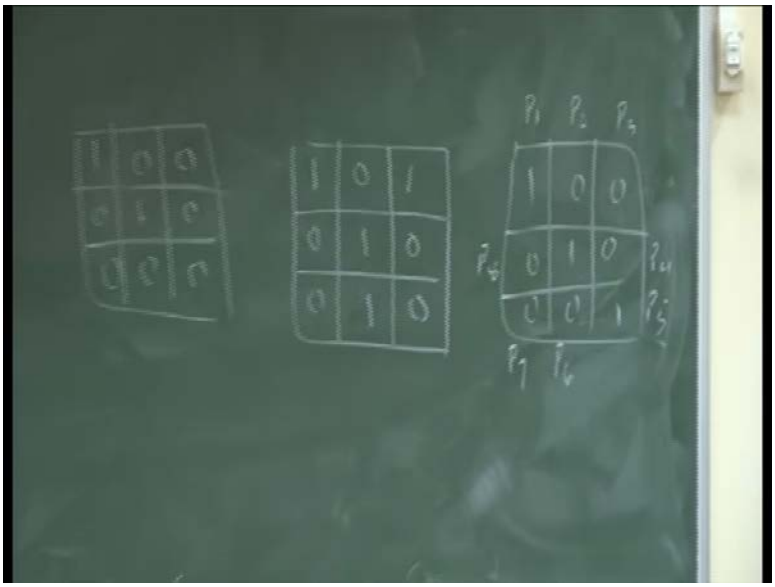

So, this will give you basically a bifurcation scenario or it need not be in this direction that direction whatever it is. But this will be a structure of your bifurcation. This will be structure of your end point. This is a continuous one and so on. So, to find whether it is a continuous line or not; what we do? These are numbered as p 1, p 2, p 3, p 8, p 9, p 8, p 1 to p 8. So, let us consider it as p 1, p 2, p 3, p 4, p 5, p 6, p 7, p 8.

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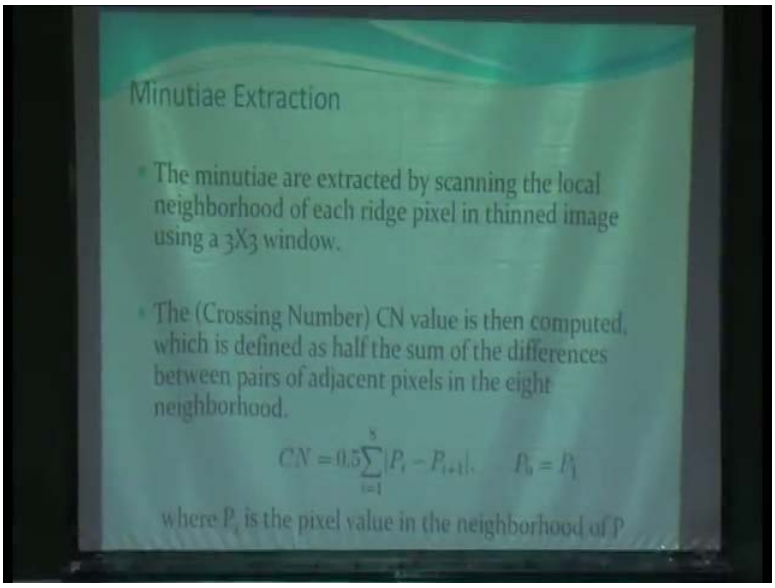

Now, this c n this is known as crossing numbers; c n can be computed by this formula 0.5 summation over P i minus P i plus 1. Why 0.5? Because the same number will be computed to y; that is the reason.

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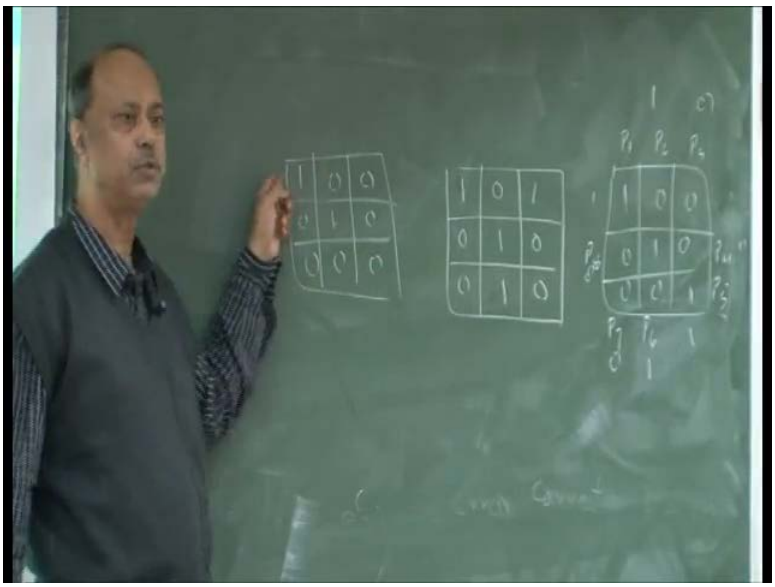

So, for this case this this minus P i minus P i plus 1. So this is 1 this is 0 this is 0 this is 1 this is 1 this is 0 this is 0 this is 1. So, how many one(s) you are getting? 1, 2, 3, 4 divided by 2 that is why 0.5, because I have considered you observe that P 1 has been taken into account because it will be combination of 0 or 1 and each line is only one but

it is a thin image. So, if this is 1 this is unlikely that this is an 1 but then if it is 1 there is a line basically. But ridges generally you do not get the ridge like this this will be like this only.

So, this is 1 plus 1 plus 1 plus 1 this four was divided by 2 it gives you 2, that means it is an even number. So, if it is an even number then it is a continuous line. Similarly, you can see it is 1 this is 1 and rest of the thing is 0 and again 1 1 plus 1 2 divided by 2 is 1 here you will find what? 3. 1, 1, 2, 1, 2, 3, 4, 5 and 6 divided by 2 is 3. So this is if it does sum of this is 3 then it is a bifurcation. If it is 1, then it is our end point otherwise it is a continuous line.

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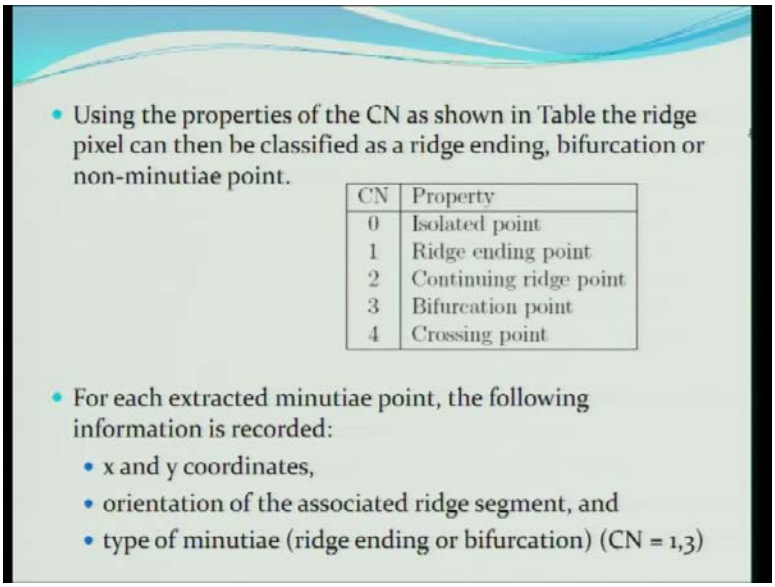

So, if it is a 0 then it is an isolated point. 0 means this all of them are 0 only 1 is lying then it is an isolated point. If 1: it is ridge ending. 2: is a continuous ridge point and 3: is bifurcation and what is crossing point?

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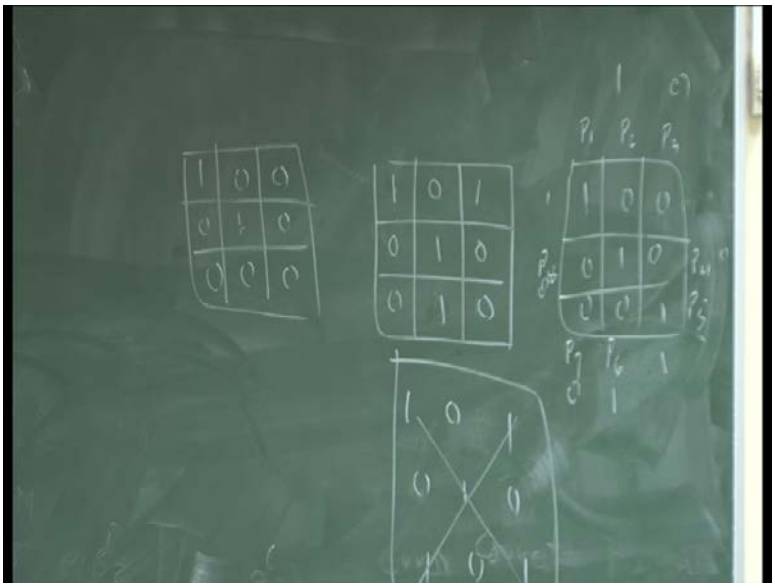

Crossing point is nothing but if it is like this. So, it will be a crossing point so, this is 4. Now, for each so we are interested for 1 and 3 and for each of them i have the x and y coordinate then orientation and finally, the type. Type means as I told you it is a whether it is a ridge ending or it is a bifurcation or not.

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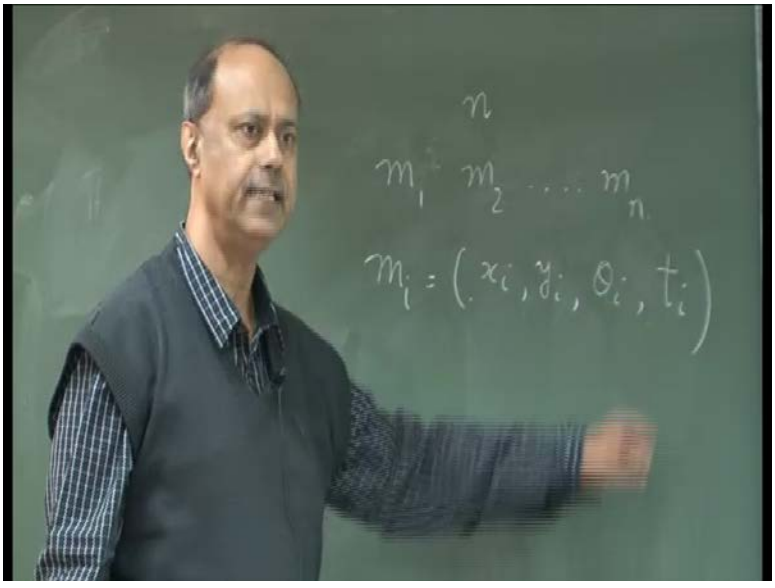

So suppose, there are n minutiae points of any fingerprint then, this is m 1 is a minutiae points m 2 is another minutiae point m n is another minutiae point; m i is represented by a triple x i y i and theta i and a type t i. This is a 4 people x i y i theta i t i agreed? Now

these minutiae points is not extracting this minutiae point is not easy. One of you who will be doing how to extract the minutiae points true minutiae points, who is that? So, that is the one thing remember it is not that easy. Why I am telling that is not easy?

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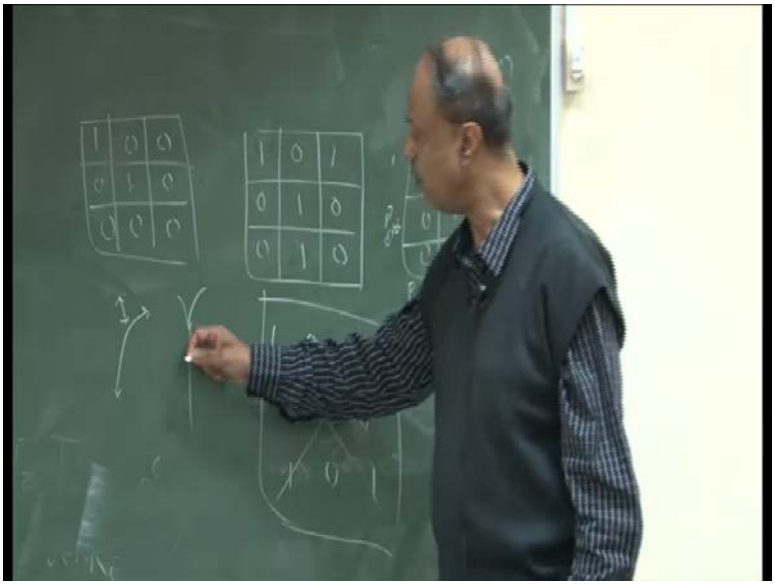

Suppose there is a noise suppose there is a noise and due to that noise suppose, this was the bifurcation point and due to this noise this is gone. So, you will be getting here one end point and here another end point here another end point. 3 end points here also another end point. 4 end points you will be getting. And also, this will be type one this is a type one you will be getting, because this is a ridge ending, this also ridge ending. So, type one type minutiae points.

Now, what I will be doing? I will be get a minutiae point, I will first check whether these 2 minutiae points are having the same type or not. If these are same type then only I will be finding the distance between these two. If the type is not same then, I will not consider. Now, you observe here that if you consider this is a type 1 minutiae point here another minutiae point here, how many minutiae points you got? 4 minutiae points. But if it was like this then, you got the 3 minutiae points and here addition one addition of minutiae points you got agreed?

And also that it is different type. So, you are not going to compare these 2. So, error will be introduced here. So, what you have to do? If you find there is a small distance between say, distance here is very small distance. What do you mean by small distance?

May be few pixels 2 pixels 3 pixels then before you obtain the minutiae points you connect that you connect that. That will give you the better or true estimate of your minutiae points. So, this is known as line fitting you fit the line and after that you obtain the minutiae points.

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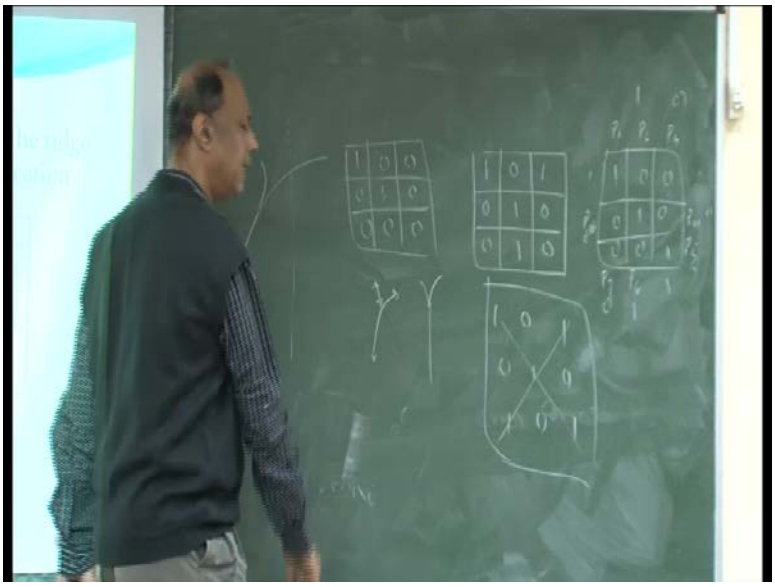

Now there is another problem you may face in that case. Suppose, you have the like this; and and there is a cut mark there is a cut mark straight line there are people you will find there is a cut. Generally, this cut is always straight line a cut cannot be like this; this is almost near straight line. So, this is a cut mark and you know this mark will also be considered as a minutiae point. This will also provide you the extra minutiae points.

Here we make mistakes, this is also this is not possible for you to determine whether this is a cut mark or not. If it is a cut mark then, you ignore it, is it clear? So, we assume that there is no in your limitation you can put that there is no cut mark. If there is no cut mark, you must be able to determine all true minutiae point that is our target rest of the things we will take care.

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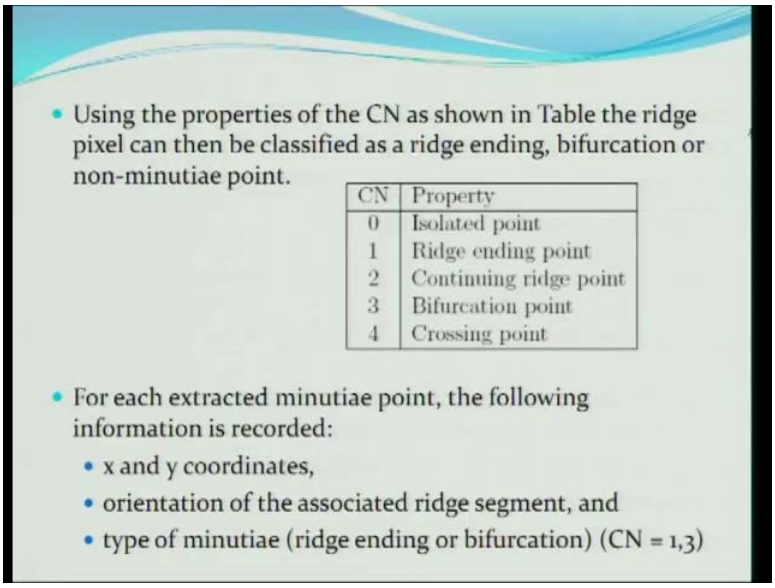

So, once you know these minutiae points, any doubt at this stage? And I told you how to define the minutiae points.

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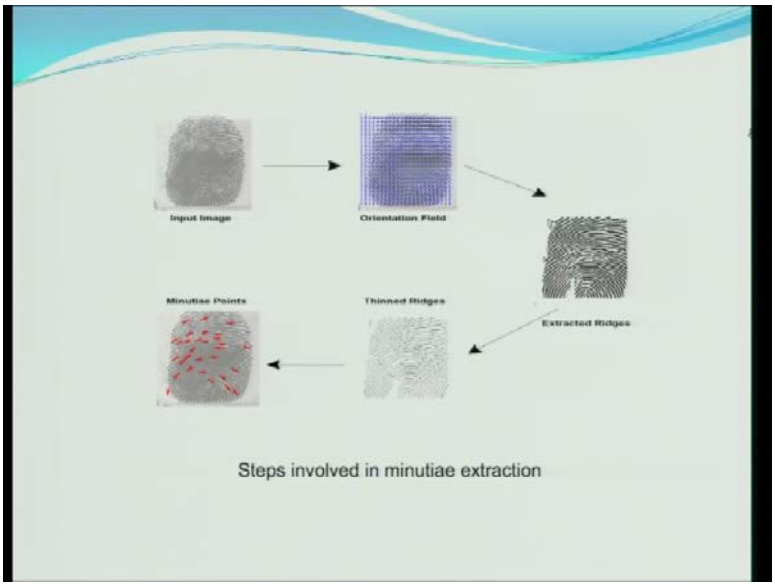

See, here you observe there is a mark which is not here. So, many minutiae points you can (( )).

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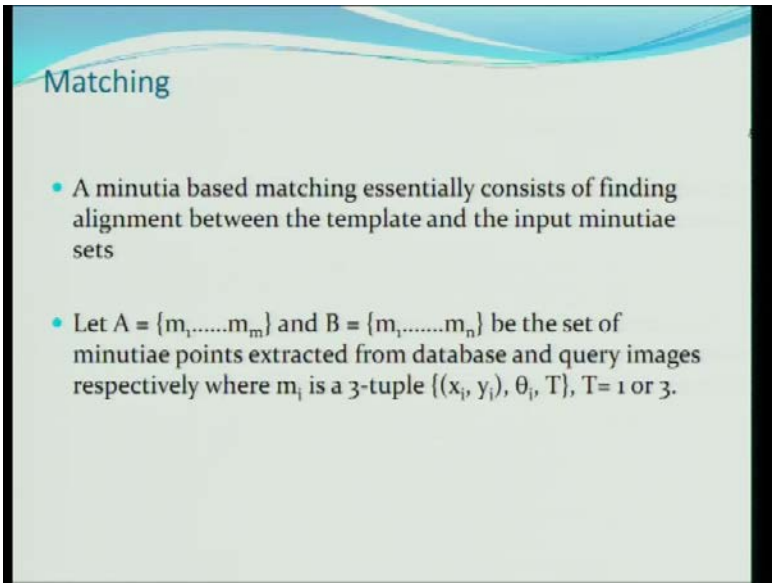

But generally it is expected that 30 minutiae points 30 minutiae points you should get at least. It will be there. Now, given two images; two fingerprint images you get the set of minutiae points.

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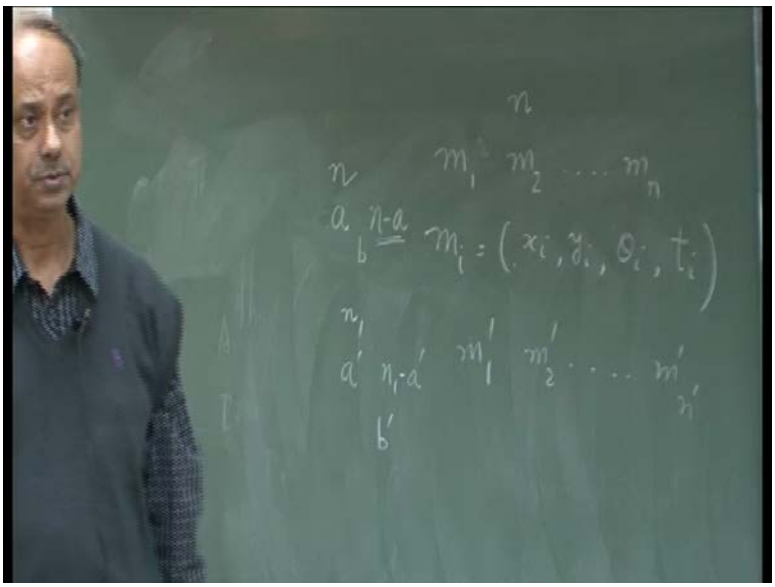

Now another minutiae points set is this. Now, you have to find out how many minutiae points are matched? So, one thing you remember this n and this n prime may not be same. So, it may have n minutiae points, it may have n 1 minutiae points. It can contain x or a true minutiae points, it can contain a true minutiae points and remaining n minus a

false minutiae points. Also, there is a possibility that it may miss b true minutiae points. a true minutiae points it has found, n minus a false minutiae points it has determined and there may be b false minutiae points.

Is it clear? b true minutiae points, which are not detected by you. Here among this n 1, it may get a dash true minutiae points and n 1 minus a dash are the false minutiae points and b dash minutiae points, true minutiae points it could not detect there is a possibility. So, if this is your aim is to his to minimize this. His aim is to minimize this. But you know if you minimize it b will also increase, that is a issue.

If you try to reduce this one you will find that you are missing also several true minutiae points. So, you will be minimizing n minus a and maximizing a, that means minimizing b which is difficult that is the issue what we are looking for, is it clear?

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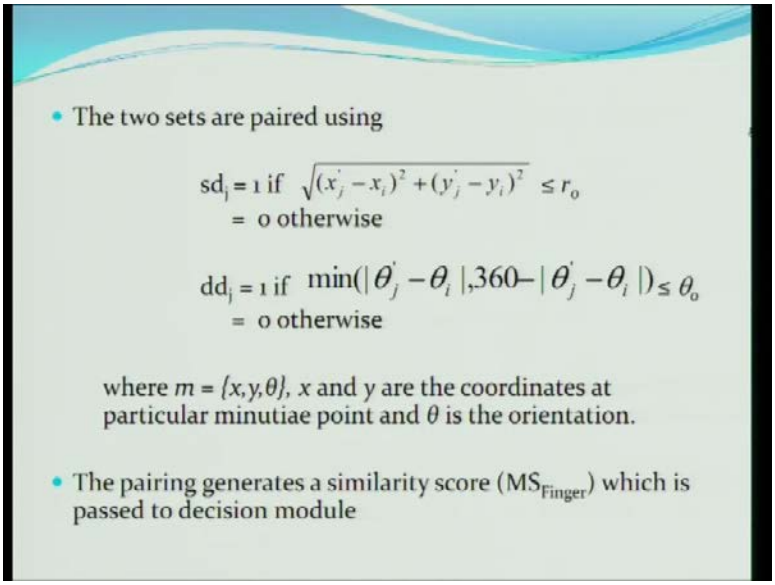

So, let a and b are the two set of minutiae points extracted from the database and querybase respectively. And you have the four triple to determine. Now, how to see whether it is matched or not? First you obtain the difference between you have the x and y coordinates so you find out the distance. One thing you remember that if somebodys fingerprint is like this another fingerprint will not be like this; this is not possible. May be five degree, three degree, four degree, ten degree it may it will not be more than that. So, first you find out the distance between the two coordinates x and y; x is the coordinate of x y is the coordinate of 1 minutiae point of the probe image and x dash y

dash is the coordinate of the minutiae point coordinate of the minutiae point of another image.

So, you can find out the distance. And if you find the distance is less than r 0 some threshold value, you tell yes these 2 minutiae points are matched and you mark it 1 otherwise you mark it 0. So, what happen? Then you take 1 minutiae point you find out among the you take one minutiae point and you find a set of minutiae points you find out what is the best match and that match if you find it is less than r 0 you tell 1 and you remove both the minutiae point from your next search one.

You take next minutiae points, again remaining minutiae points you have, you matched whether it is there exist or if it is there and removed and so on. Later on you will find what? That for one you will be finding n 1 search then second one n 1 n dash minus one third one n dash minus 2 and so on. And now, how many of them are matched? You can find out if that number is less than threshold. Then only you can tell yes it is matched. So, that is the thing you are telling that, if it is less than this and also there angle is also less than some threshold value, then you tell yes that element has been matched you go for the next one and so.

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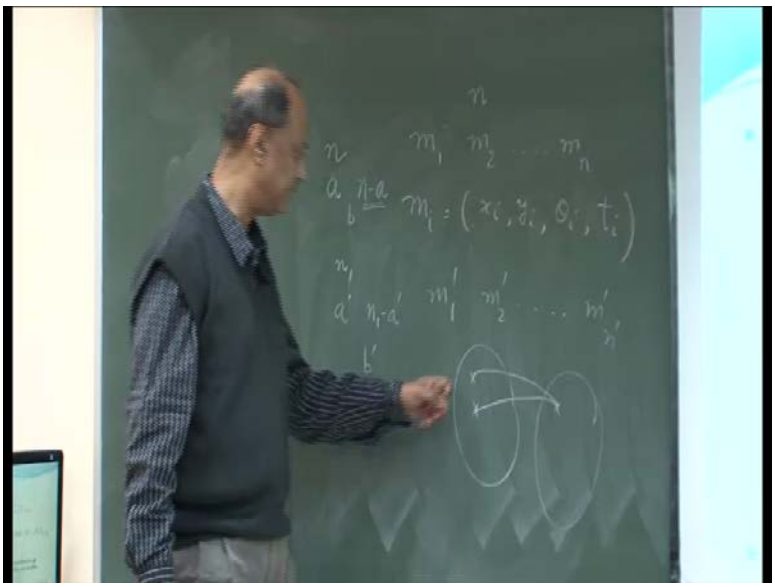

Why I am introducing this one? There is a possibility that 2 m one is also matching m you know you have one set like this and this is another set this is m 1, this mapping is there that may also occur like this. Which one you are going to consider that matched?

This one with this one or this one with the this one? So what we are doing? We are checking also the angle. If angle is less than the threshold you tell, yes not only the distance match it is angle also matched then you select that this is selected. So, both these elements will be removed from my search area.

Then next one I will take again I will find out that whether there exist a closer one or not. If there exist a closer one then you check whether it is less than some threshold value or with respect to the angle. If it is so then accept or otherwise you throw them out also and so on. Finally, how many one(s) are there? That you have to determine; if number 1 is less than threshold value you tell, it is not matched if it is exceeding some threshold value you tell it is matched.

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Type? Yeah of course, type first you will be taking the same type. These are all (Refer Slide Time: 22:31) within the same type; type is the highest one. If they are not same type then, you are not going to unnecessarily going to do this.

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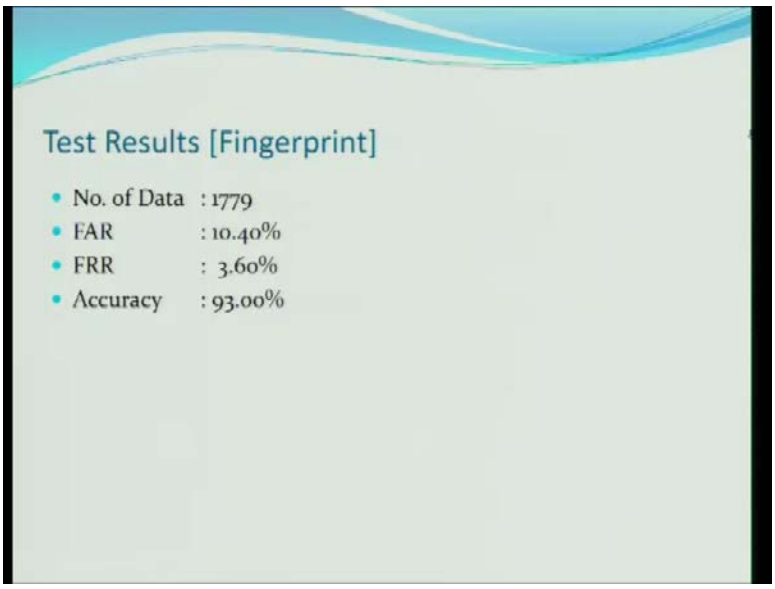

Now, in our case we have tested again 1779 FAR is very high, FRR is moderately good accuracy is 93 percent.

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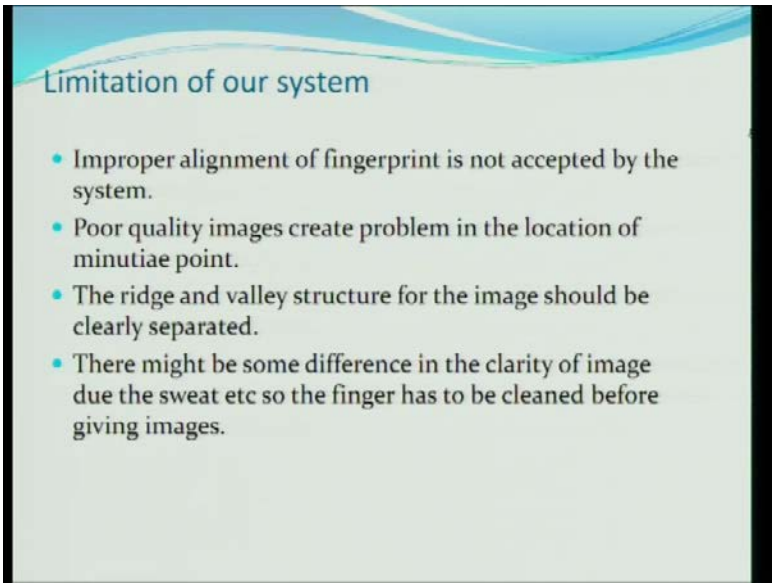

What are the limitations? If it is aligned improper alignment then the system creates problem. Now, what do you mean by alignment? First one is that if I put my finger I this way or this way or I put little tilted one. Then, it will create problem or if the angle is too much it will give you error. Poor quality image create problem in the location of minutiae, this is true because the quality of image suppose this is smudged one.

Where is the bifurcation point? It is very difficult to determine. That ink pad or ink based finger print is the one example, where it is very difficult to determine the minutiae points. Then there are some cases you know i do not know whether some of you has raised that dry fingerprints, then if you have a thumb print and you get the ink on your finger then, you put it and after sometime you find that some part is becoming dry is not visible but some part is very good.

So, that is also another problem that from that you know if you try to improve or enhance the image the other part, wet part also get enhanced. And if you remove something then, your dry part will go away. So, you have to compromise between these two; the ridge and valley structure of the image should be clearly separated, that is a smudged one.

Sometimes, because of the ink that it covers the valley part. Then because of weather you may find that images are distorted. So it is not possible to extract the minutiae points. So, aim is your common aim is to extract the minutiae points first efficiently. Once you can extract the minutiae point you are through rest of the thing is very simple. So, his task is

to he will be giving me are you going to give us that. Are you going to give us the true minutiae point now? You will be giving right? Very good that is the thing I am looking for and if you do it I will be the happiest person. So you know if I am happy then what you are also happy. So give it and our test data is ready that data, I will not give you, any other query on fingerprints?