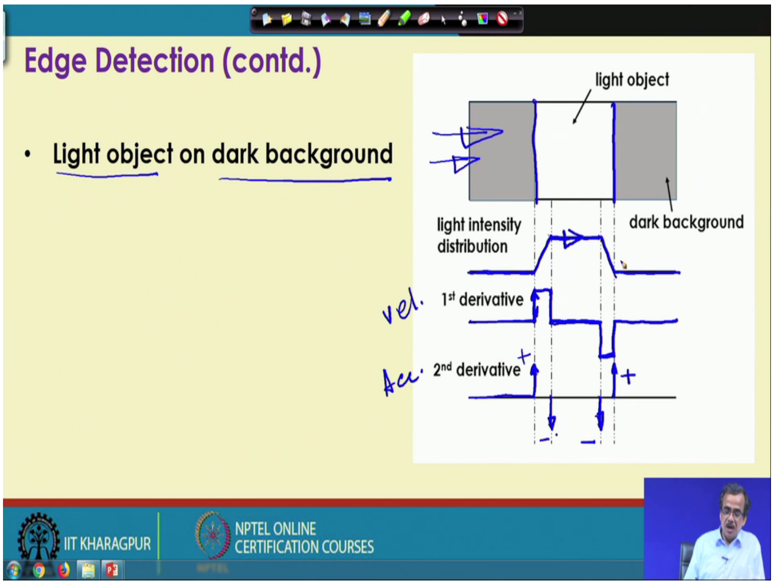
Robotics
Prof. Dilip Kumar Pratihar
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 36
Robot Vision (Contd.)

(Refer Slide Time: 00:19)



We have discussed that for edge detection we can use the gradient operator like 1st order gradient or the 2nd order derivative. Now here let us see what is happening physically; if I consider the 1st order derivative or the 2nd order derivative during the edge detection.

Now, once again let me consider the light object; let me consider the light object and the dark background. So, this is actually the dark background the black one is the dark background and here; so I have got the light object. Now if I just do the scanning along this particular direction and try to find out the light intensity value; so if I just do the scanning in this particular direction. So, I will be getting; so this type of light intensity distribution.

So, up to this black portion the light intensity value will be small and in the light zone actually the light intensity value will be more. And once again in the dark zone the light intensity value will be less and in between actually here; so, this particular light intensity value is going to increase and it will reach the maximum. And here starting from here the light intensity value is going to decrease and it is going to reach the minimum value. So, this is actually the distribution of light intensity if I do the scanning in this particular the direction ok.

Now, the moment we are taking the help of gradient operator that 1st order derivative. So, what happens is you are here; so, there is no change of light intensity value; that means, your the rate of change is your 0. So, this indicates your 0 then comes from here to here; so, from here to here there is increment there is increase in light intensity value and this particular rate is constant, this is the straight line. So, it has got the constant slope; so, this is actually your the amount of your the 1st derivative.

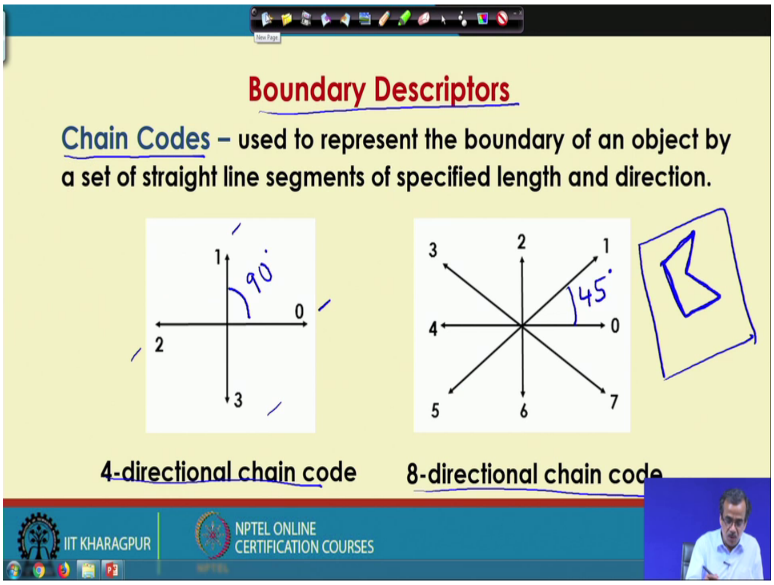
Then comes your here; so, from here to here there is no change in light intensity. So, once again this will be the distribution for the 1st derivative; then from here to here there is decrease in light intensity; that means, there is one the rate for decrement and that particular rate is constant. So, this is actually the constant rate of decrement and then it is your 0; the rate of change is 0. So, this is actually what we mean by the 1st derivative of this particular the change in light intensity.

Now, if I consider the 2nd derivative; let us see what happens. So, up to these there is no problem, so this will become 0 sort of thing ok. So, here there is suddenly there is a change; so, the rate of change. So, it is actually if you see this is nothing, but the positive sort of thing ok. So, after that this will remain same then it is going to be reduced. So, it is going to be reduced; so, I will be getting some sort of negative sign here ok. Then from here to here; so, this is the rate is 0; so, there is no check now once again from here to here there is further decrease. So, here there will be an arrow in the negative and here suddenly there is an increase. So, this will be the positive that is plus ok.

So, this is what is happening on the 2nd derivative. Now if I just compared to the; so, this particular distribution of light intensity with the displacement. So, this is nothing, but the velocity and this is nothing, but the acceleration sort of thing ok. This is actually what is happening, the moment we are using the gradient operator like; 1st order derivative or 2nd order derivative as a tool for the edge detection.

So, this particular derivative is going to detect this particular edge. So, this edge will be able to detect between this light object and the dark background with the help of this gradient operator. So, this is the way actually this particular the gradient operators are working just to detect that particular the edge.

(Refer Slide Time: 05:23)



Now, I am just going to discuss the concept of the boundary descriptor. Now before we start discussing on this particular descriptor let us try to understand the reason behind the going for; so, this boundary descriptor.

Now, these boundary descriptors are used just to represent the boundary of this particular object. Supposing that I have got say on the white background say this is the background and on this particular background, supposing that I have got one object something like this.

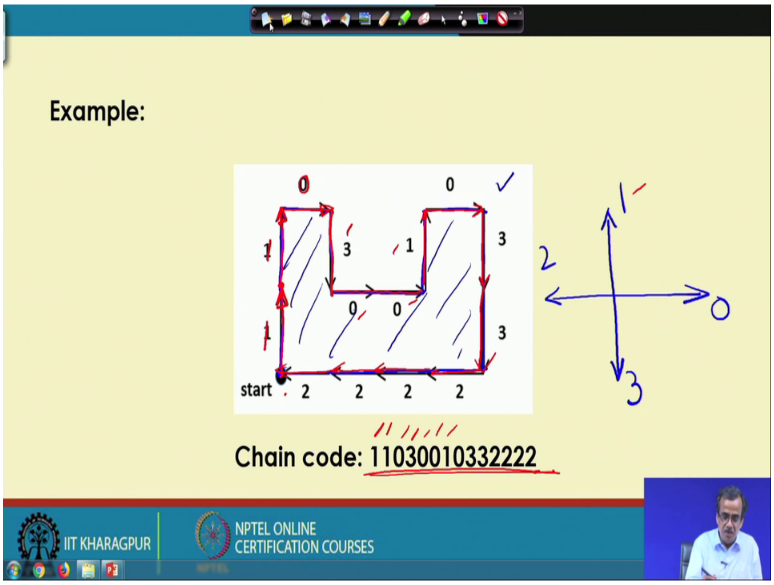
So, if I have got this particular object now the boundary of this particular object I will have to represent for further processing. Now; how to represent so this particular, the boundary? Now to represent the boundary actually we take the help of the boundary descriptor and if you see the literature we have got a few boundary descriptor. So, here I am just going to discuss 2 boundary descriptor in detail and these are very frequently used.

The first one that is called the chain code; now, here the boundary of the object is represented with the help of some straight line segment of pre specified length and direction. So, what we do is we generally take the help of either the 4 directional chain code or 8 directional chain code. Now let us try to see what is there in 4 directional chain code; it is very simple it shows only 4 directions denoted by 0, 1, 2 and 3 and they are 90 degree apart.

So, this is the 4 directional chain code and if I take the 8 directional chain code starting from 0; 0, 1, 2; up to say 7. So, this is called the 8 directional chain code and here the included angle is 45 degree and here the included angle is your 90 degree.

Now, to represent the boundary of the object; if I take the help of say 8 directional chain code; so, there is a possibility that we will be able to represent the boundary more accurately compared to the 4 directional chain code. Now let us see how to use that the 4 directional chain code or 8 directional chain code to represent the boundary.

(Refer Slide Time: 08:15)



Now, here I am just going to use one 4 directional chain code just to represent; so this type of the object. Now supposing that; so, this particular thing this is nothing, but say white this is the white background. So, this is the white background and here we have got one object whose boundary is something like this.

Now this particular boundary; so, I will have to represent with the help of some numbers or mathematically so that we can do some sort of your the processing; the further processing ok. Now to represent; so this particular boundary in the computer program; so we will have to use some set of numbers because computer program does not know anything except this particular the numbers ok.

Now here supposing that the object the boundary of the object is something like this; so, this is a very simple example. Suppose is that this is the object the boundary of this particular object and this particular object is a say dark object. So, this is the dark object on say light background ok.

Now, how to represent this particular the boundary or the object? As I told we are going to take the help of 4 directional chain code. So, this is 0; this is 1, this is 2 and this is your 3 and let us start from any point; let me start from here. Now if I just start from here; so if I just start from here. So, this is the starting point now from here; so I will have to move along the boundary; now this is the direction of 1. So from here to here; so I move along the direction of 1; by how much amount? By some pre specified the fixed length ok; so, I will be here.

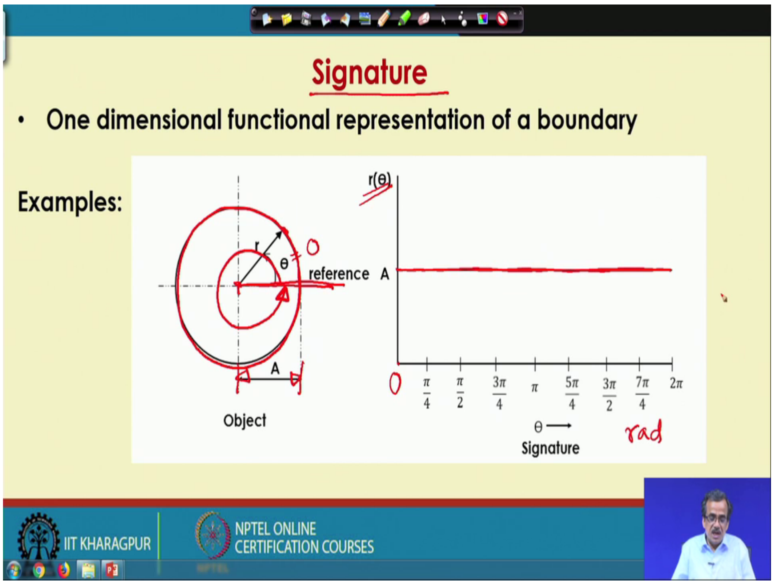
Now, from here; so, I will have to reach this particular point, once again I will move along this particular 1. So, I will be writing 1 here; then from here; so I will be moving towards my this side ok. This is the direction of 0, so here I will write 0 and from here I will move along this particular direction this is the direction of 3; so, I will have to write 3 here.

Then from here, so this is once again the direction of 0; once again second from here to here the direction of 0, then from here to here; so this is nothing, but the direction of 1 ok, this is the direction of 0 this is the direction of your 3. So, this particular direction this is the direction of 3 then from here I am just going to move towards that towards 2. So, this is the direction of 2, 2, 2 and I am just going to reach this starting point.

Now, to represent this particular boundary; so what we do is we just go on writing all such numerical values in this particular the sequence. For example, we start from 1. So, I have got a 1 here next is 1, next is 0, then comes here 3 then 0 0 0 0 then 1, 1 and we follow that and then we will be coming back to this and we have got 2 all such 2s here.

So, this particular numerical value is going to represent this particular boundary of the object ok. And in a computer program; so, this particular object will be represented like this and then we can do the further processing with the help of your the computer programming. So, this is the way actually we can represent the boundary with the help of some boundary descriptor.

(Refer Slide Time: 12:26)



Now, if you see the literature we have got some other type of boundary descriptor also and that is known as the signature. Now signature is actually nothing, but the functional representation or the mathematical representation of a boundary of the object.

Now, let me take a very simple example of say circular object; now if I take a circular object for example, say this type of circular object I have got and I want to represent its boundary. Now how to represent? So, what we do is; we try to find out its center. So, this is the center and this is the reference line with respect to which I am just going to represent the fixed reference ok.

And r is actually the distance between the center and the point lying on this particular boundary of the object. So, this r is the distance between the center and the boundary point and I am just going to start from this particular reference where theta is made equal to 0. So, corresponding to this particular reference theta is made equal to 0 ok. So, theta is made equal to 0; so, this is in radian.

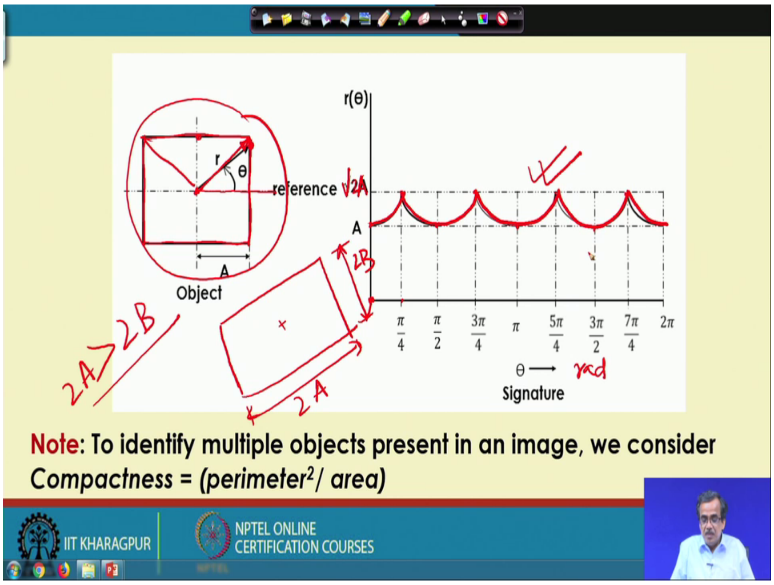
So, all such things are in say radian this corresponds to your say 0; this is pi by 4 means your 45 degree, pi by 2 with respect to these; so this is 90 degree; then 3 pi by 4, pi 5 pi by 4, 3 pi by 4, 7 pi by 4 and then 2 pi. So, I will be coming back ok.

So, 360 degree rotation and here so as I am moving along this particular the theta ok; so, the distance between the center point and the point on the boundary is kept constant 2 is equal to A; A is nothing, but the radius of this particular the circle. So, A is the radius and the distance between center and the boundary that is nothing but r.

So, if I plot r as a function of theta that is nothing, but is your r theta. So, there is a possibility that I will be getting one straight line because starting from here up to here. So, the value of r that will remain same as your equal to A that is nothing, but the radius. Now, this particular straight line; so, this is up the straight line; so very easily can represent mathematically ok.

So, this is nothing, but like your say r is equals to A that type of equation ok. So, this particular your, is going to represent; so, this circular object lying on the computer screen. Now this particular circular object with the help of this equation we can represent and then we can do some sort of the further processing; this is actually your the method of the signature.

(Refer Slide Time: 16:06)



Now, let me take another example just to make it more clear; so, I am just going to take the help of another example ok. Now here supposing that I have got one object and this is nothing, but a square object. So, if I take a square object like this; so this is nothing, but the square object and if I take this type of square object and A; 2 A is actually the dimension of this particular side and that particular side.

So, I can find out the distance between this particular center and the point which is there on this particular boundary and that is denoted by r and this r as a function of theta; so, I can plot. So, this is theta in radian and theta corresponds to 0. So, this is the reference; so I am here, so if I am here then this r theta is nothing, but this is equal to A.

So, corresponding to this particular theta equals to 0 ok. So, r is nothing, but A; then corresponding to theta equals to 45 degree. So, I will be getting; so this is actually the distance between the center and the boundary and that is nothing, but is your root 2A; so, this is your root 2A ok.

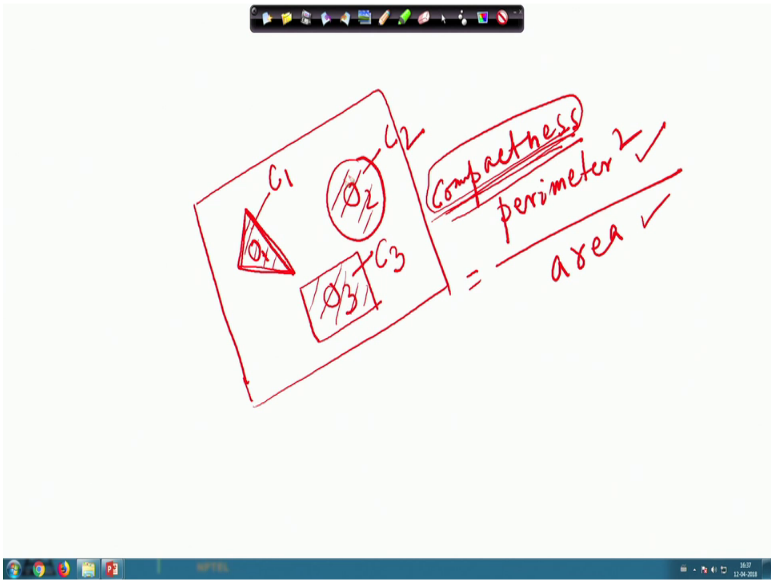
Similarly, at pi by 2; so, at pi by 2; that means, I am here. So, once again r is equal to A then comes 3 pi by 4; that means, I am here. So, once again it is root 2A, then pi corresponding to pi. So, this will be your A then once again here it is root 2A; A root 2A; A and so on ok. And this particular distribution will be non-linear distribution, so there is a possibility you will be getting this type of non-linear distribution of r theta with respect to your theta ok. This type of distribution will be getting for this particular corresponding to this type of your the square of object.

Now in place of square like if I just take the rectangular shape for example, this type of rectangular shape. So, once again I will be able to find out for example, this side is say 2A and this is your 2B and supposing that 2A is greater than say 2B or A is greater than B and for corresponding to this; we can also find out another the signature.

So, corresponding to this particular the square object; so, this is the signature which we are getting and once you are getting this type of plot now it can be expressed mathematically. And if I can expressed mathematically then further processing becomes easier. Now, I am just going to discuss like how to identify the multiple objects which are present in one photograph or in one image.

Now if I just take; let me take a very simple example then after doing all such calculations, supposing that I am just going to get one scenario for example say this is, this is the background.

(Refer Slide Time: 19:56)



And on this particular background; supposing that I have got one object like this, I have got another object like this, I have got another object like this ok.

So, this is object 1, this is object 2 and this is object 3 and I have taken the photograph and the way I explained; I carried out that image analysis and ultimately on the computer screen supposing that I am getting so this type of image. For example, this is nothing, but the object it is a black object and white background sort of thing. So, I am getting say this is the black object and a white background; so, I am getting, so 3 objects on this particular the computer screen.

Now, how can I identify that this is object 1, this is object 2, this is object 3? Now to identify that; so, what we do is for example, with the help of our eyes whenever we see the picture of the environment so or the surrounding we very easily we can identify that this is a chair, this is a table, this is a human being and so on. So, immediately within the fraction of second there is lot of processing in the brain and due to this particular the processing; we are able to identify this particular the objects.

Now, how can computer or how can one robot identify that this is object 1, this is object 2 and this is object 3? Now the method I have already explained and this type of objects we are getting. Now actually what we do is, we try to calculate one parameter that is called compactness now this particular compactness is nothing, but perimeter square; perimeter square divided by the area.

So, for this particular object; so we try to find out perimeter square by area that is nothing, but the compactness. For example, if I have got a chair if I have got a table if I have got a human being. So, in our brain actually this compactness this particular information is already stored. And that is why very quickly within a fraction of second we can identify that this is a chair, this is the table and so on ok. So, all such information has been stored in our actually the brain.

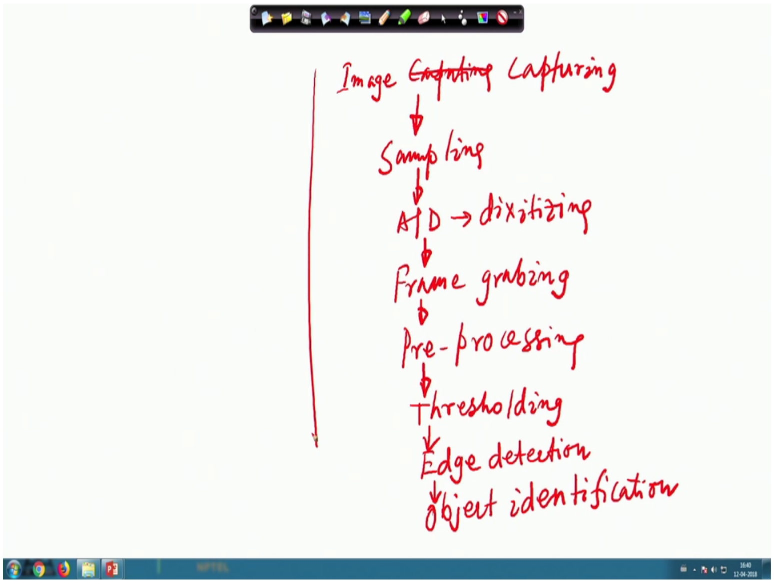
Now, here actually for this artificial image processing or the artificial computer vision or the robot vision; what we do is for each of this particular object; we predetermine what is their compactness values? Now on the screen we are getting the background and the object. So, approximately I can find out what is the perimeter of this, what is the approximate area I can find out perimeter square by area.

So, I can find out the compactness; supposing that for this particular object 1 the compactness is C 1, object 2 the compactness is C 2 and object 3 it is your C 3. So, this we can calculate from this particular computer screen and we try to match with our the known values of compactness of object 1, object 2, and object 3. And then we try to recognize and we interpret we identify that this is object 1, this is object 2, this is object 3.

So, this is the way actually one computer or a robot can identify, interpret the different objects. Now if the robot wants to do some sort of manipulation task; it will have to identify, it will have to interpret the objects ok. And the way we human being carry out our this the vision system; exactly the same way we try to copy in the artificial way, in computer vision or the robot vision just to collect information of this particular the environment.

Now, once again if I just summarize little bit this computer vision or the robot vision what they do? The first thing is do is, we do is we try to capture the image. So, we capture image; so, image capturing in the first stage.

(Refer Slide Time: 25:00)



So, image capturing with the help of camera. So, we try to capture; capture we try to capture this particular image capturing with the help of camera and once I have got this particular image.

So, what we do is; we do some sort of sampling and for this particular sampling we take the electron beam scanner ok. And we generally go for analog to digital conversion and that is nothing, but the digitizing. So, we generally go for the digitizing and once you have done it; we go for the frame grabbing. So, we go for the frame grabbing and once I have got this; so we go for the preprocessing; preprocessing.

And once the data have been preprocessed then we go for some sort of thresholding. Now once you have done this thresholding, then we go for some sort of edge detection, edge detection and after this edges have been detected; we generally go for object identification; so, object identification.

So, object identification; so these are the actually the steps for the computer vision or the robot vision; exactly the same thing we do; we human being do. And in computer vision or the robot vision we try to copy everything in the artificial way so that we can collect the information of the environment. The robot can collect the information of the environment with the help of camera and we will have to make this particular process very fast. So, that within a fraction of second; so, we get the information of this particular the environment.

Thank you.