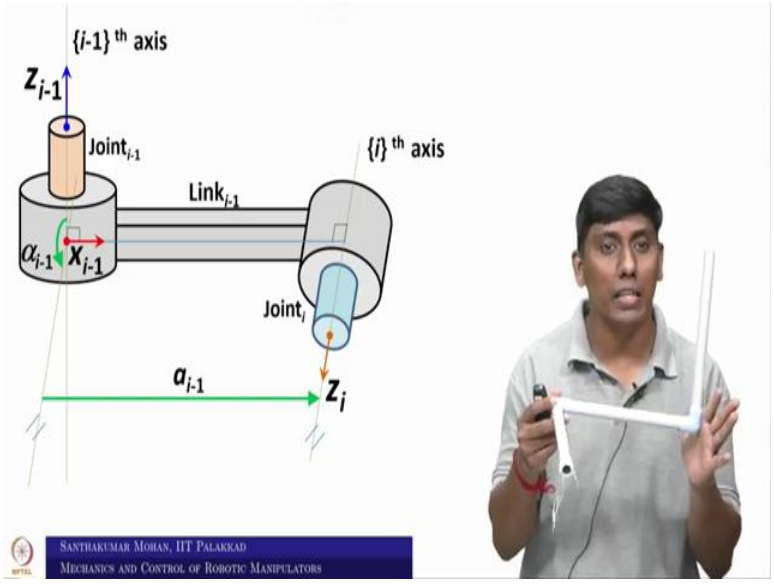
Mechanics and Control of Robotic Manipulators
Professor. Santhakumar Mohan
Department of Mechanical Engineering
Indian Institute of Technology, Palakkad
Lecture No. 09
DH Parameters

Welcome back to mechanics and control of robotic manipulator. So, last class we have seen like Denavit-Hartenberg parameter, mainly we call kinematic parameter, there are 4 kinematic parameter. So, two would be link and two would be joint. So, where we said that the link parameter we call it is relative information of two consecutive joints. So, in the sense, we said that the relative information of two consecutive joint can be expressed in terms of one angle and you call one distance.

So, we will see like that, how we can actually like pictorially we can represent and as well as physically how you can feel it. So, for that we are taking one link you can see, so this is what we can call as a link now. So, this is a random link which is we call link k, or you can say link i minus 1.

(Refer Slide Time: 1:00)



So, now you can see that this is a random link. So, this link would be having actually like set of things, so you can actually like put it you can see I am actually like showing it. So, this is what now become link. So, now this link is having something like arrangement. So, very simple

arrangement which you can see one elbow is actually coming towards you, one elbow is actually like pointing upward.

So, now, this link would be having what so, so many joints. So, as per the Denavit-Hartenberg, what it says any link supposed to be a binary link, so in that sense it would be having two joints. So, what are the joints you can see? So, these are the two joints, so these two joints I am actually like pictorially represented there that physically I am showing that this is one joint, and this is another joint you can actually like see it.

So, now if I connect this you can see like, one joint is actually like going upward another joint is actually like going inward, in the sense it is pointing inwards to you. So, now this is link i minus 1. So, this is a link sorry, this is joint i minus 1, and this is joint i. So, this joint i minus 1 would be having you can say link i minus 2 and link i minus 1. So, this, this link what you call this link link i minus 1 on the joint i it would be connecting.

So, one more link so which is actually like what you call, so this is link i so this is link i and this is link i minus 1 and this is link i minus 2. So, now in that sense, if you take a random link, you can say this i minus 1. So, what you can see it would be having two joint axes. So one is actually pointing out you can say up, so that is what we call joint i minus 1. So the other one is actually like joint i.

So, now as per our you can say Denavit-Hartenberg approach what we can see these two joints are supposed to be fixed in you can say axes. So, this is actually like can be rotary, or actual like a translation joint, but what we can actually like see that these two axes are supposed to be fixed with z. So, in the sense Z i minus 1 and Zi would come. So now what it is giving, so this link i minus 1 is giving a relative information of this joint i; this joint i and joint i minus 1.

So, now you can see that these two are actually like oh you can look at it in the front view you can see these two are actually like angle apart and in the front view you can see it is distance apart. So, first we will actually like attempt to what is the joint angle apart, or you can see the angle apart, so these two joints. So, for that what one supposed to do? We have to draw common normal between these two, what you call joint axis.

So, I am doing that so now what you would did, so we draw on a common normal between these two axes, which is actually like coming on this line. So, now in this line, if you look at it, what

you can feel it. So, this is actually like a traveling line and as well as you can see that with respect to that you can rotate either this, or this you can rotate.

So, now we are actually like taking this line some axis. So, what axes as per the Denavit-Hartenberg? So, on the link, so you will take link parameter would be represented with respect to x axis. So, in that sense this you can say common normal what you have drawn, so on that you can actually like fix the x i minus 1 axis. So, now what you can see this is what you are joined i minus 1 and this is your joint i.

So, the common normal you are drawn and this is the point what do you call the frame point. So, now the point which is actually like coming towards your i, so, that is what you call x i minus 1. Now with respect to this what you can do? You can actually like rotate this. So, you can look at it. So, this is actually like you are x i minus 1. So now you are actually like rotating.

So, now what one can see this is joint i and this is joint i minus 1. So, in the sense what one can see you can rotate this much angle and make it parallel. So, that is what we are actually like doing it. So, what first we are doing it, so this is what your joint i minus 1 and this joint i so I draw a parallel line from this point. So, now I drawn, then I rotate, so that is what I did. So, how much angle I rotated with respect to this.

So, this is actually like with respect to this axis you are rotated, so alpha i minus 1. So, the alpha i minus 1 positive direction also you know so that what we have actual like done here. So, now, this is giving one angle, so these are the two you can say joints this is two states. So, that is why it is called link twist. So, this is with respect to link. So, these two joints are twisted, so that is why it is called link twist.

So, this angle represented as alpha i minus 1, this is about X i minus 1, angle between Zi minus 1 to Zi, what you call link twist angle. So, now what else is remaining? You can see like the distance between this point to this point, so there is actually like a travel across. So, in the sense what you can see, so you can actually like go across and then see it.

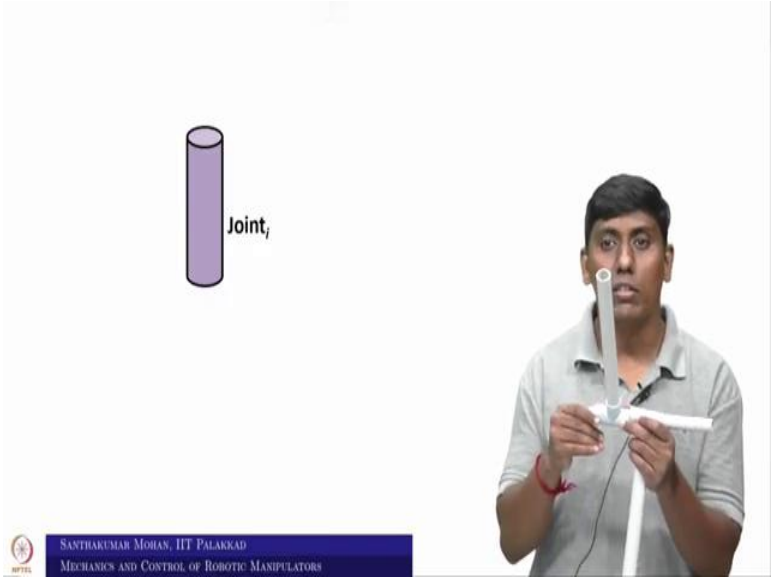
So, now this is what the distance, which is what you call a i, if you are actually like a representative with respect to i minus 1 frame, so this is a i minus 1. So, in the sense the frame distance in the sense you have Z i minus 1 and Zi. So, the angle between these two what you call

alpha i minus 1, the distance between these two about are along x i minus 1, what you call link length.

So, why it is called link length because this length is actually like zero what you can see these two frames are actually like in the same point. So, now there is a physical length, it is actually like distance apart. So, that is why we said the physical length cannot be negative. So we have to take xi minus 1 always and now progressing side. So that is what we written in the previous lecture. So, a i minus 1 should be always positive, or 0.

Now, you got these two what you call link parameter. So, one is actually like angle between Zi minus 1 and Zi about xi minus 1 that is what you call link twist. So, it is nothing but a twisting of these two joints about this link. So, that is why it is called link twist. So, the other one is actual like that these two axes, how much distance apart along x i minus 1 that is what you call physical length, which is nothing but link length.

(Refer Slide Time: 7:30)



Now the same way we will actual like see what you call the joint parameters. So what are the joint parameter? So joint parameter, we will talk about the relative information between two links. So, now we will take a random joint, so for that I am taking a random joint. So, now this is actual like we call actually like a joint. So, this joint is actual like joint i.

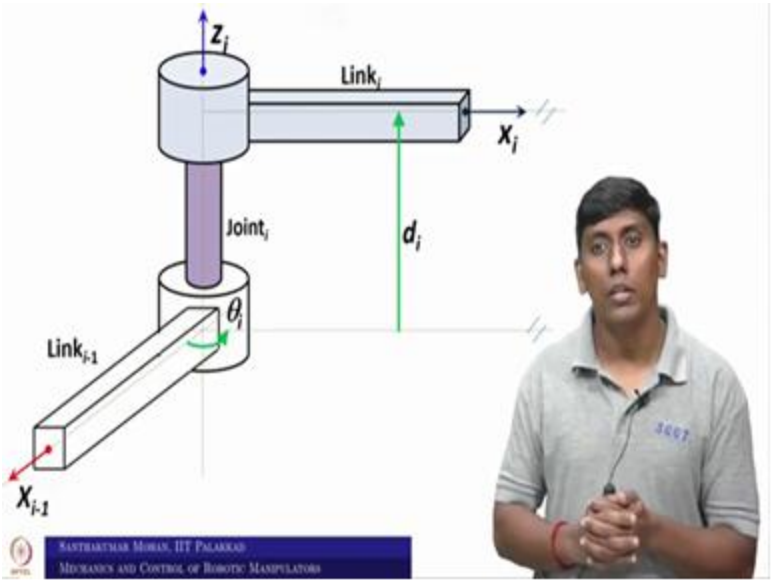
So, now, I have actual like taken the same thing in the picture, you can see this is what the joint, which is nothing but a PVC pipe there you can see a cylinder. So, now this joint is connecting

what, so there are two bodies. So, one body and another body. So, now what you can actual like look at it. So, this joint will give a relative information between these two joints. So, how much distance apart, and how much actually like angle apart.

So, if you look at in the front view, or you can say you talk it this as a top view, you can see that these two links are actual like angle apart. So, if you look at it in the front view, you can see these two links are actual like distance apart. So, you can actual like look at it. So, this is what the distance and this is what the angle.

So, now these two, you can say parameters that you call the joint angle and the joint length, or you can say we call that is joint distance can be expressed on what so this joint axis. So, whatever this, this is what going to represent.

(Refer Slide Time: 8:57)



So, that is what we are trying to explain here, you can see that these are the two links we have connected. Now, these two links are actual like free about this joint, it can actual like a translate, or it can actual like rotate about this. So, now you can see like these two links supposed to have some you can say phenomena. So, first what we will fix, we will fix the joint access. So, as per the Denavit-Hartenberg, this joint access is actually like Zi. So, now Zi is fixed.

So, now the link would be having what? Link parameters the link would be having Xi and X i minus 1. So, that is what we fixed here. So, now you can see that this Xi which is actually like going here and X i minus 1 is going here. So now if you look at in the you can say top view. So,

you can see like these two are having angle apart. So, that is what you can actually look at it in the figure, the angle between Xi and X i minus 1 what you call joint distance, joint angles.

So that is what we are trying to do, so for that we are actual like making a Xi parallel line at the you can say link i minus 1, and you are a virtual like a drawn that. So, now what you can see the angle between these two what you call joint this joint angle. So, this is actually like you can see referred with respect to the particular you can say joint axis.

So, now what is joint angle, so you can assume that these two are actual like a parallel. So, now it is rotate at what would be this. So, now theta i is there, this is what you are joint axis. So, now you can see like the theta i is there. So, now what is this joint distance? The distance between these two you can say axes. Now, what it look like? It is actually like look like it is a off planer, how much it is actual like offset between one plane to another plane.

So, that is why it is commonly called offset distance, what you can see? So, you can see like this is link i minus 1 and this is link i. So, how much it is actual like planer offset this much distance. So, which axes you are referring Zi. So, this is what the you call joint distance, or offset distance. So, the angle you can see in the top view and the distance you can see what you call from the front view.

So, now, this is what the joint distance, so that is what we have actual like written I hope now it is actually like clear. So, what is Denavit-Hartenberg parameter, so where you can take a random link, so that link would be having two joints axes. So, these two joint axes information which is giving that is what you call link parameter. So, this link parameter is constant, or you call it a geometric parameter, because once you fix the link, so that link cannot be changed.

So, in the sense you take actual like one random link, that link configuration will not change time to time whereas, you can take the joint. So, the joint would be actual like connecting two consecutive links. So, now the relative information between two links would be given with a joint. So, that is what you call joint distance and joint angle. So, that actual like refer to joint access which is Zi whereas, the link parameter is the geometrical parameter that referred with respect to you call Xi minus 1.

So, now you got the clarity between what is linked twist, what is link length, why link length is actual like it should not be you can say negative, you got the physical feel. Similarly, what is

joint angle and what is joint distance, why joint distance is called as you can say offset distance, these all actual like I hope you are clear.

So, whenever you call theta, so theta refer to i, d refer to i so in the sense you are referring to the joint axis, which is Zi. So, in the sense theta i and di would be corresponding to either free whereas, you can say the link parameter that is actually like trying to relative information with respect to i minus 1 to i. So, it is actually like travel along and rotate about, so in the sense xi minus 1.

So, alpha i minus 1 and a i minus 1 this mix to what we call you can see nonstandard, if it is actual like you refer everything with respect to in the single you can see representation that what we call standard frame. So, now I hope you are actually like got clarity on this.

So, the next lecture would be Denavit-Hartenberg representation, we would be moving towards the forward kinematics. I hope that would be very useful for you further on. So, with that I am ending this lecture. Thank you and see you then, bye.