Lecture 15 : Experimentation V

Hello everyone. I am Puspendra Gupta, a PhD research scholar in the department of echanical engineering IIT Kharagpur. Currently I am doing my PhD under the guidance of Professor D.K. Patilhar and Professor Kalyanmoy Deb. So, today, I will be performing the experiment number 5, path and gait planning of 25 degree of freedom θhumanized robot.

You have already seen the previous videos, where we have performed the experiment on the different type of robots such as manipulators, agricultural tractor vehicles, hexapod and drones. You are already aware that the manipulator are having the fixed base and they cannot move from one place to another. However, they are extremely popular in the industries because of their capabilities of handling various tasks that are repetitive in natures. Whereas the mobile robot such as our tractor vehicles and hexapod, drones are capable of moving different currents and environment while completing the task at hand.

However, they cannot use the tools and equipment made for the humans. Particularly in this course we are really going to find such a robot that can replace a human in a real world scenario especially for the dangerous and tedious task. So well if you really try to analyze that which robot is going to replace a human-being, then the answer is simple, a humanoid robot. And the reason is that a humanoid robot act and look like a human because it got all the body parts that a human has like head, two arms, two legs. Now a humanoid robot due to that it closely resembles a human being and have a capability of performing a task equivalent to a human being.

So human being sorry the humanoid robot particularly can also walk on the plane surfaces, climb the staircases, cross ditches and take turns as the situation demands. However, at the same time these are also capable of using different things that a human use such as doors, any sort of switches, handles, etc. This is the reason they are also able to interact with a human being in a very natural and friendly way. So, this particularly make them very suitable for the applications for the education and health care sectors. Now since they are also able to handle the equipment that is made for the humans, they can be replaced for some of the dangerous tasks, where a human life could be extremely dangerous.

Something like bomb diffusion, rescue operations, disaster relief, chemical handling or going anywhere that is extremely hazardous for a human life. So, particularly in this experiment, I am going to use the non-humanized robot to demonstrate some experiment. And this particular non-humanized robot has 25 degree of freedom, has different types of sensor that is extremely useful to perform some of the advanced tasks. And this particular it is a very advanced robot and extremely popular in the world in the domain of humanized robot. So I will be using this particular robot and I will be I am going to show you at least around 5 tasks.

So these tasks I will be performing using the choreograph software. Choreograph software is a graphical interface software where we can plan any sort of movement or control the humanized robot. And apart from using this choreograph software we can also use different programming languages like python, c++, java and all these programming languages are extremely efficient in controlling the different part of the non-humanized robot. So with this demonstration I hope you will learn something new about this in this particular course and we will really try to explore the capabilities and limitation on the non-humanized robot and this is this would be a very good opportunities for any researchers or any student to learn more about these bipedal robot and I hope you will learn something really new in this video. Thanks a lot.

Thank you so much. So we are going to perform the task 1. Identification of different moving joints of the NAO humanoid robot. Let us first identify different parts. So as earlier we have already discussed that a humanoid robot is the one that really looks like a human.

So it also got a humanoid shape like it got one head, two arms and two legs. So the humanoid robot has one head and in the head it contains two cameras, two speakers, four microphones. I do not have knowledge of the French language. Sorry. So this is the one camera, this is the top camera and this is the bottom camera and both cameras can be used to see and recognize the object in the real time.

Whereas the speaker are these two sides are able to produce the sound and the microphone is used to hear a sound. And then we have these two arms is made up of the six degree of freedom whereas both the legs having five degree of freedom each. So there is one more joint it is called the hip yaw page joint and this is the common to both the legs. And this is the torso we have one button and this is the button, which is used to switch on or switch off the now humanoid robot. So after that I will be also trying to use the one choreograph software.

Choreograph software is used as a graphical interface to program the humanized robot. So I am going to show you. So I am going to use choreograph software to move the different part of the now humanized robot. So before that we need a choreograph software and the choreograph software is available on the algebra dot com website. So here if you go to the website we have to go to the downloads and in the download we will see the choreograph.

And in the choreograph it is available for the different platform like windows, mac and Linux. And once you install it and download it once you download it and install it then you will get this type of interface. So I have already installed it so this is the interface and this is called the main box or where we most of the time program our NAO humanoid robot. And this is the virtual 3D NAO humanoid robot I can drag it, here I can maximize it, and you can also see here, this is the video whatever the now humanized robot is able to see it. And, then, I am going to move the different joints but before that I need to connect the real humanized robot to our choreograph software.

For that I will be going to here in the connection mode and you will see that this is the first one is the virtual NAO humanoid robot. The second one is the real humanoid robot and this would be only visible if you connect a LAN wire or you can connect it wirelessly. So for the time being I have connected it using the LAN wire and this is the LAN wire that has been connected to the NAO robot and then once the connection has been made we have to select the real **NAO humanoid** robot and click on the select. Once we do that I have already selected so I am not going to do it again once we have selected so this now robot is going to be connected to the choreograph software. Now if I click on any part of the joint you will get a one joint inspector and the joint inspector you will see that the head is having six joint from the shoulder pitch shoulder, roll elbow, yaw elbow, roll wrist, yaw and hand.

And, before the first word L R represents the left or right side, so these two arms are having six degrees of freedom, whereas if I click on the leg, we are also having six degree of freedom but the thing is that these five degree of freedom from the hip roll to ankle roll, these are all the independent to each other, but right hip yaw pitch and left hip yaw pitch, these two joint angle are common to both the legs and here this is the torso and in the neck, we can see that there are two joints. So, now, if I am going to move this joint and you will see that in the real humanized robot, it is going to be affected, so I am going to head yaw and it is going to look sidewise, similarly hip pitch we can move to when the robot wanted to see either below or toward upward, so here I am moving this joint and you can see say that the joint joints are moving and this thing is visible in the virtual humanized robot as well as in the real humanized robot. So if you want to move the arms joint, we again, we can experiment it and I am going to move the shoulder pitch joint and if I move the shoulder pitch joint so we can say that it is lifting its left arm, and then, for the right arm we can lift it in the same software, so this way you can visualize it, how each joint angles are and what are their function how we are moving it and this way you will be able to see that its movement, however, for the time-being, I am not moving the left joint angle because there is a stability issue, if I move too much the robot may fall on the ground so however you can do it by again going to the connection and then only switch to the virtual robot once virtual robot has been selected, so even the robot is not able to extend on the ground, it won't affect because the real robot is not going to be affected much so in the task one we have learned that how to install the Choreograph software, how to use it to move the joint what are the different joint, how we can utilize it and in the next task I am going to move the humanoid robot and I will show that how to use the graphical interface to move the robot forward backward or for the turning motion, thank you so much. Task two moving now humanoid robot forward backward and taking a turn, so for that we will be using again the Choreograph software so again on the Choreograph software we have to program it to move the robot forward backward and taking a turn for that if we see here, we can find that there are different box libraries are available and I am using different behaviors to program those commands so here we can see that there are lot of libraries are available like animations speech, LEDs, multimedia, movement, sensing and programming so for the time being I am using the movement in the movement and under the navigation folder I am taking the move to behavior and if I consider the move to behavior then here at the setting we can see that it is asking for the different parameters these parameters are the distance x in meter, distance y in meter, θ in degrees, and if you hover the mouse on the values, so it will also inform that what these values means so particularly for the now humanoid robot, we really wanted to see that what are the x and y directions and what is the θ direction, so if we come to the NAO humanoid robot, so the particularly x axis is in the forward motion, whereas the y axis is in the toward the left hand side so toward the left hand side y axis is the positive, whereas x axis is positive toward this side and z axis is positive toward the upward side, so I wanted to move the now humanoid robot in the forward direction by one meter so I have to give here this parameter should be set to the one if I wanted to simultaneously move the NAO humanoid robot in the y axis, so these two parameters should be set according to those two values and then θ is the if you give the positive value then the robot is going to move or turn toward the left hand side or a negative value means it is going to turn toward the right hand side so here I have also used one more behavior this is the say command or the say behavior say behavior is nothing but here I have to fill some text and these steps are going to be created by the NAO humanoid robot so here particularly we can make, we can use the say behavior to make the NAO humanoid robot more interactive, so particularly I am using the move to behavior of one two three four four times so in all those four times the first time it is going to move in the x direction in the posterior direction by one meter that means it is going to move forward by one meter in the second move to behavior the value I have set to minus 0.5 that means it is going to take a backward motion by 0.5 meter and then in the third move to behavior I have set our θ value to a positive 90 degree and the rest of the values are set to be 0 so the robot is not going to be moved either in x or y direction but it is going to take a turn toward its left direction and left side by 90 degree and then, in the last move to behavior I have set this particular θ value to a minus 90 degree, so to again just like we have already in the previous video we have discussed how to connect the robot in a similar fashion we have to connect the real NAO humanoid robot by by clicking on this network button and then by selecting the real humanoid button and then go to the select and after that if I hit this play button then this particular button going to upload the robot upload the program onto the robot and it is going to compile and execute the program onto the NAO humanoid robot so I am going to hit this particular play button but before that you can also see all these box libraries these are all the ready-made code and in the next steps I will also try to tell you how to move the joint panel and according to your own requirement for a time being I am going to run this particular command, so that it can execute our desired motion hello I am going to walk forward by one meter, hello I am going to walk backward by 0.5 meter, I am going to turn left by 90 degrees hey I am going to turn right right by 90 degree, so we were able to use the Choreograph software to move the NAO humanoid robot either in the forward direction or in backward direction are further taking a turn and you can also plan some more complicated motion according to your own use and according to your own requirement so thank you so much and the next task we will surely learn more about how to make much more complex movement so see you in the next video thanks a lot. Task 3 we are going to perform a task dance movement on the NAO humanoid robot actually dancing is a little bit extremely complex movement because it require a synchronization and coordination of the different parts of the of a robot so particularly NAO humanoid robot is going to use all of its 25 degree of freedom to execute this particular dance movement and we will be using a timeline box and a Bezier function to create a continuous and smooth motion, so that it can moves in all of its limbs in a very nice way so that it may look like a very synchronized movement and later on, I will explain that how you can individually moves according to different frame using the timeline box for a time being I am going to take you to the Choreograph software, how this particular dance movement has been planned so this particular program is little bit complex, so here I am already I have prepared this particular dance timeline and if I double click on it I can show you that this is the all the key frame and later on I will in the next task I will also explain that how to program this particular key frame so if you click here you can see that there are different type of if I click on the curves you can say that these are the different types of motions that are going to be planned in a particular time frame, so if I click on the left arm, so these are all the motions that are going to be executed on the left arm, if I expand the left arm and only go for the shoulder pitch angle so this is the shoulder pitch angle movement and then, this is the shoulder yaw angle and then, these are all the elbow angle, so this is a little bit complex but for the simplicity in the next class I will show you how to program it, so I am going to run this particular dance movement and you will see that how actively it is going to move its all of the body parts, so if I click on the road I am going to go to the original format and then, I am going to hit the play button so it will going to execute the whole program on to the I want to play just with you, I am a pretty good girl nice to meet you, I really like the count 3, 4 are you a winning man? Big shot, twin get your wallet you can 5, 6 I am looking for a guide 4, I am chopping 3, I am a guide 7, 8 my name is Eddie B, I am the angel thanks for giving money, so you have already seen that this was an extremely complex movement and it required all the coordination and all the synchronization of the different body parts and it was able to execute it, so in the next task we will also try to execute our own program and I hope you enjoyed this dance movement thank you task 4 we are going to control the NAO humanoid robot joints at a different time frame for that we will be using the timeline box and how to do it again we have to use the choreograph software, so on the choreograph software, I can right click here and go to the new box, so suppose, I am creating a new box and here I am getting a different type of box like diagram timeline, phyto, dialog so I am going to click on the timeline in the box name I can put like suppose let us move the arms, so I can put the arms movement and then, in the description you can write anything or you can left click, so if I double click on it so you will get one time frame and then, these are all called key frame timing and here, I can fix any joint at any location and at about 20 key frames it makes about one second so accordingly we can plan our movement at different time frame suppose I wanted to start from here and at particular 10 second whatever joint I have whatever movement I can see here I wanted to fix as this particular 10 key frame, then I can simply right click here and then store the joint in this particular key frame so here I am getting four option one is whole body and the other is head arms and leg so I am going for the whole body if I click it here and if I hover my cursor on this particular key frame then I can see that these are all the various joint I have saved there so suppose I wanted to move move my right arm to add some different location after moving it I can go to the key frame at 25 and again I can say say these joints in the arms so these particular left arm has been saved here and these are all the joint movement that I have moved here now once again I can click at anywhere and then again store the joint in the arms and I can keep going on the number of times so suppose up to the hundred key frame I want to plan my motions after the hundred key frame I can go on and then here there is one red flag this is showing that the motion is going to be added at this particular position so on the motion tab if I click on the edit button so you can see that whatever joint movement I have shown here it is showing those graphs to visualize the graph it is a much easier in this particular frame so after clicking on the curve there are this is the parent directory that you can say the parent directory under the NAO robot, if we got a different parts like head left arm right arm left leg right leg and in the head if I click on the head so I am I'll be getting this type of these points so in the head I have not planned any motion so I am getting only a single dot however I can again plan this motion by inserting a key frame so if I insert one particular key frame here though I have not restored any joint in the head so I am not getting any joint but for the left arm I have stored it so here you will get all the joints like in the left arm I am getting all the one two three four five six all the joint movement here, so suppose in between this particular key frame and this particular key frame I wanted to add one more key frame, so after right click here I can simply click on the insert key frame but for that you have to highlight this particular curve now if I right click here again and click on the insert key frame, then I am going to get one more point and this particular point is movable I can move it here or there and you can see that there is a bit of reflection because the curve is here and the point is floating here it is showing that the limitation of the joint has been reached and this particular arms movement cannot go beyond this particular joint if I move this particular joint to a lower then you can see that it is now is smoothly connected to this particular curve so similarly I can again move this particular point here or there and accordingly these particular head movement on the real robot as well as on the virtual robot can be seen in the real time suppose I wanted to to make this particular joint to a very close to 50 degree I can very easily do that because there is a grid however if suppose I wanted to make it to 55 degree so I can directly put here 55 degree once I put it here so this particular joint is directly going to the 55 degree so I can add any more point and I add there would be one Bezier function so suppose if I click it here so this particular joint has been is smoothly connected to each other and and I can manipulate any other other joint so to show you this particular motion I have already prepared one program I am going to directly open that program called the hand movement and the hand movement you can see that I have taken different keyframe like two keyframe are here two keyframe are here two keyframes are here one keyframe are here so so if I again go to the editor so you can see that there are different movement I have planned so in the left from this is the motion that I have planned and I am really interested in moving only the shoulder pitch right so this is the moment of the shoulder pitch right and you can see that how the robot is moving itself so the pitch line and this particular joint is responsible to move the arms in front and then in the upward direction and I have also used this particular elbow joint and I have set it to the negative values, so elbow I have kept as a straight, so I have not bent it so only to show you that how to plan the directory I have simply going to manipulate the shoulder pitch joint, so I have started from the 80 degree and by 80 degree because when the robot is stretched its hand in the forward direction this is the zero degree, so if you go positive then the robot is going to lower its arm in the downward direction, if it is negative then it is going to move the sound in the upward direction, so here from the 80 it is going to the zero, zero means in the stress position pointing to the forward direction and once again the second keyframe is also at the same zero degree because we wanted to hold the position at this particular particular point and then I have moved the joint to the negative, negative means it is going to move its arm in the upward direction and then again this particular keyframe is very close to this joint and after 100 of keyframe unit that means the arms is going to be hold and in this particular position then again I have bring it to the zero, then again it is going to be moved in the forward direction, forward means it is going to stretch its arms in the forward direction it is pointing its arm in the forward direction and then again it to the plus 80 degree that is again going to the move downward, so if I run this particular command so it is going to take at around 10 to 12 second in moving in lifting its arm and then it will hold its arm for the five second and again its move its both the arms to the upward direction then again it is going to hold it for about five second so this is a very simple equation but this can be utilized to move the joint at according to our desired for our desired actions so this is the right arm similarly in the right arm I have also planted a shoulder piece for the right arm and then this is for the left leg and this is the right leg so here I am going to run this particular program and we will see see that how it is going to perform so you can see that this is particular NAO human robot has lifted its arms and it is pointing in the forward direction now it will lift itself to the upward direction and hold it there for five seconds then again it is going to bring back its arm in the same position and it will lower its arm to the downward though this is a very simple activity however this is extremely beneficial when we are really wanted to plan our joint angles to a different value in a different time frame suppose we have some we have already planned some gait we did, some gait planning and we have some joint angle for the left and right right right legs and we wanted to move according to that particular gait planning so we can feed in the same fashion the way we have fed for both the arms, so I hope this way you have done something new how to plan our joint trajectory I hope it will be beneficial for any type of research activity thank you thanks a lot. Task 5 so we are going to perform the task 5 it is about accessing the different sensor values using the monitor software so for the monitor software we have already installed the choreograph software and while installing the choreograph software you will notice that you have already got one monitor software, if I double click it so you will get two option one is memory and that is camera so after clicking on the memory it is again showing that for which robot you are wanted to monitor the its sensor value so I am going to select the real humanoid robot after selecting it it will ask me for the new configuration file or you wanted to use open the configuration file so if you do this you can also save it is in a CSV file but for the time being I am going for the do not use the config file so if I maximize this particular thing you will get all the different sensor values here so in the sensor values you will get two things one is called a watch and that is called the graph for the watch you can also utilize it within the choreograph software like if I go to the view so here within the view I can click on the memory watcher and here it will say that select the memory click to watch if I double click it so here you will get a lot of option, lot of sensors values, so for the time being if I select anything suppose let me see let us go for the position values, so these are all the suppose I am just simply clicking on the position values, so if I click on the OK, so you will get all these values so this is the heavier position values so you are getting in the radian and if I move this these ones then this particular values are going to be changed, so here you can watch it as in the real time whenever I am changing it, so here this is given in the degrees but the unit here is followed as a radian, so if I click on the memory software in the memory software I can once again go to click on these values and if I click on the watch then again it is going to show me the numerical values, if I click on the graph it is going to plot the graph in the real time so whenever you are running any program and you want to access any sensor value then you can use it so for the time being let us suppose visualize any so these are all the joint angles and here I am getting one option as a electric current electric current it will show that how much current is consumed by a particular joint angle, so let me first go for the position value, so I am going for the this let us plot the knee pitch value, so new pitch values I am going to plot it using the sensor value, so if I plot it, so this is the knee pitch value for the left leg and for similarly for the right leg I can plot it, so here this is the this is the right knee values, so at the same time I am plotting these two joints and once if I move the robot then these joints are going to be fluctuated, so I am going to run this particular program and I will show you how these particular joints are going to be moved, so you can visualize it and for that I have made one program, where the robot is going to walk to diagonally because I have given, I have given the values in the x direction as a one and the y direction as a one so both direction H 11 means the robot is going to move forward one meter at the same time it is going to move towards its left side by the one meter a ball thing is combined that the robot has to walk diagonally so I am going to run this particular program and I will also turn it this monitor to show you that how these joint angles are going to be varied. So, in the same fashion if suppose I wanted to measure the left knee pitch, the electric current how much current has been consumed by this particular joint then I can click it and you can also see that this particular variation is shown here, however you have to also be very much careful about the scaling of these values because these values is only varying between very close to zero and one value is varying between a much higher value, then the other might be appear as a straight line because due to the lower variations so accordingly we can click on any other sensor to visualize it here and this is extremely helpful in order to if we have planned any type of gait movement and we wanted to see that how other sensors values for the center of pressure on the x direction or y direction on the left leg or right leg it is varying this is extremely helpful.

So, this particular task for the task 5, so we have completed it how to access the different sensor values using the monitor software. Thank you. We have already completed 5 tasks on the NAO humanoid robot it has really shown that how we can use the choreograph software to move the NAO robot to access a sensor value to make it to plan this joint trajectory and now I wanted to say that there are different sensors on the NAO humanoid robot like on the head we got a tactile sensor whenever we touch it can feel and we can also program these particular using this particular tactile sensors and there are bumper on the leg it can be used to avoid the obstacles there are these four sensors it can be utilized to detect how much away is our obstacles and accordingly it can avoid it. So, particularly in this additional task we wanted to explore its own capabilities in how it can interact with sound environment. So, I am going to speak to the NAO humanoid robot and it will we will see that whether it is able to interact with us or not and this will also show that how it is on speech recognition is working and where it can be utilized for some sort of healthcare professionalism or some in the education mode or any other thing where it can assist people to go at some places.

So, I am going to try it. Hello. My name is NAO. Introduce yourself. My name is NAO. I am a humanoid robot and I am 58 centimeters tall.

I was born at Softbank Robotics in Paris. Sing a song. Okay. That's it.

I forget your name. What is your name? I'll tell you again. My name is NAO. Okay. Thank you. Now, we have explored the capabilities of this NAO humanoid robot and I would like to conclude this course.

Thank you. Thank you so much for watching me on this NPTEL course.