NPTEL Online Certification Courses
Industrial Robotics: Theories for Implementation
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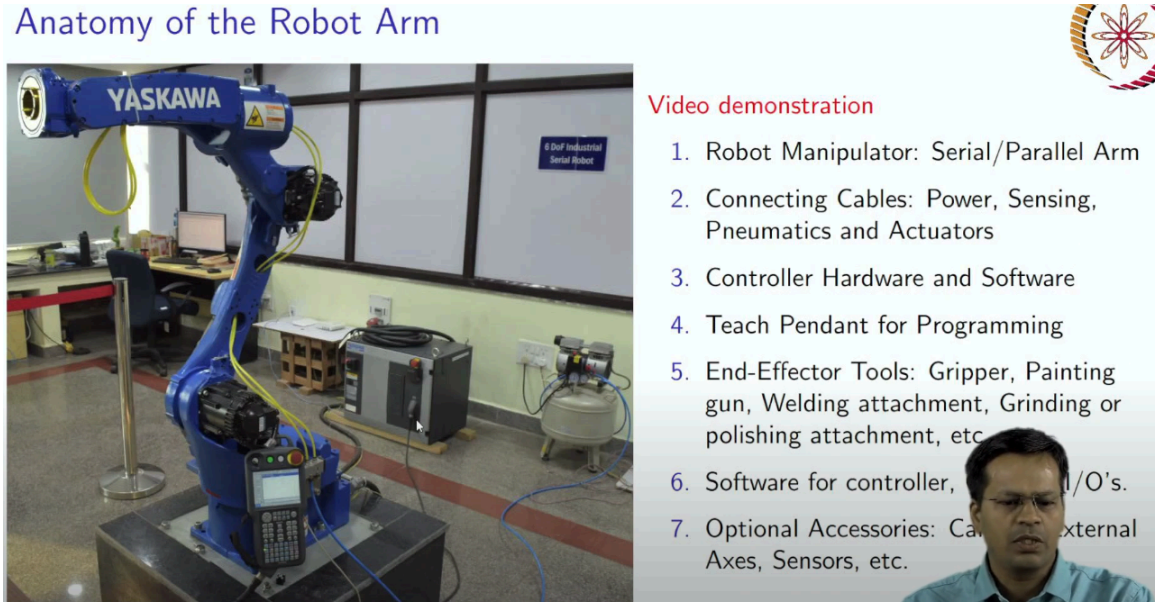
Anatomy of an Industrial Robot

Welcome back. So, let us start with the anatomy of industrial robots. In this lecture, we will be covering the different parts of the industrial robot. A robot is basically a hardware which actually performs the task. It is mostly a mechanical unit with some electromechanical actuators or sometimes only electrical actuators, right? It also has a hardware device which is basically a controller (electronic controller) which mostly processes the power. It controls the system. It has a closed-loop system. It also has some interfaces to external devices, mostly teach pendants, sensors and actuators. So, we will look at different components that make it, and we will also cover the teach pendant, which is the programming device which is normally attached to any standard industrial robot.



So, let us just watch the small video that I have from my lab. It is the robot that you see. It is a hardware unit. Looks like an arm, which is 6 degrees of freedom. So, you see, this is having a first axis that is the first motor that is sitting at the bottom, a second one, a third motor which is there that is at the shoulder joint, And the fourth one you see that is for the elbow joint and then you have two additional actuators which basically makes the wrist part of it. These are the six electrical actuators which move the system. It is an electrical robot, basically, and you see, at the centre there is a hole. There is a special hole in the robot where that allows passing cables, wires, ducts, pneumatic wires and also, sometimes, arc welding wires.

It is the end effector flange where you can put different tools. Overall, it is your hardware which is there. It has the end effector two-fingered gripper. You see, it has a flange which exactly fits onto the top of the end effector of the robot. These are the two pneumatic inputs where you can operate this pneumatic gripper. Now, we have placed it exactly at the top and see it has a standard flange, which is governed by international standards; I have made it go a little down so that I can see from the top. Now, you see from the top there is a marker where you can put the supplementary load. Any additional accessory will go on that particular link.

Yes, so this is the teach pendant which is there. We will explain very much in detail, and this is the hardware controller which is there. We will look into this also.

It is the software which actually forms inside the GUI portion of it so that you can program something extra apart from a standard, which is pre-loaded there. It is the Robot manual, which helps you to understand various important things which are there which is useful for programming, and this is our typical input-output cable. I will show it inside the controller and also how it is fitted. It is just an additional space that I had I am

showing it here. So, this is plugged into the IO board, and finally, you get to see some input and output with which you can control the robot.

So now, what components that you have seen is an industrial robot arm. It is the serial robot arm, and then you see some cables, cables for power, cables for sensing, pneumatics, some actuators, controller hardware and the software you have seen is basically installed inside this hardware controller. Teach pendant, which is used for programming. We will get into the details of this teach pendant and various parts of it. The end effector tool that I have shown you is a gripper; it can be a painting gun, a welding attachment, or a grinding or polishing attachment also, as you have seen in the application videos earlier. The software controller has a GUI to handle different inputs and outputs, and optional accessories can be there, which is not a standard part of a robot when it comes to you. It can be added on with a camera so that you can decide something based on the camera, which is commonly known as a machine vision system. External axes can be added apart from the standard 6 degrees of freedom axis that you have in this standard robot. You can have an external turntable, let us say, which is also controlled with the same controller so that everything can be synchronised. And then there are some input and output where you can have various sensors apart from standard sensors which are already there which is required to run this type of robot. So, these are things that you have seen just now.

Now, let us go to the controller part of it, which is the hardware controller. So again, let me just switch to that window. So, this is the hardware controller that you see externally; it looks like that. So, the teach pendant is in a docking position. For the teach pendant where it is, keep it hanging. Normally, if you go to an industry, this teach pendant is not always visible. It is normally attached when you actually want to make some changes to the program which is already there or you want to create a new set of programs for a given application. Once it is done, it can be taken out for safety reasons so that nobody can tamper with the codes and all.

So externally, what you can see here is your switch, the main switch, which is actually contacted inside. I will show you inside also. Do not worry, this is the external lock. Now, here we went in. So this is the electronic contactor. It is the switch from where three-phase electricity is getting in. You can see red, yellow and blue wire, that is three phases of electricity that is getting in here. From here, it goes to the contactor, and the electronic contactor is here.

This part is an inverter, which is also known as the converter. So, I will write it down over here; let us see. So, this is your converter, or it is in electrical terminology, it is also known as a rectifier, rectifier which is here. So, it has various outputs.

From the top, you see it has three phases of electricity that is getting in, and then it is converted to DC. If you go through my lecture on actuators, you will see this type of motor actually converts three-phase electricity to a DC one, and again, it has an inverter that is also part of this controller where it converts it back to variable frequency electricity AC power which is going to the AC synchronous motor Which is AC servo motor. So this is a part of it, so this is a rectifier and you see it has various input and output, various outputs which are there. It is the earthing you see, which is very necessary for this to run.

It major part that you see here is basically the CPU. It is the CPU of this kind of robot central processing unit. You see, it has an Ethernet cable which is connected so that I can communicate it from any outside PC or some sort of signal if I have one. And over here, this is the electronic servo controller, and this is the servo pack known as the servo pack. So, the electronic servo controller, this is the electronic servo controller right that is controlling all the six axes you see here is 1, 2, 3, 4, 5, 6 independent controllers are within this pack which controls all the six joints of your robot. Now this part, this part is basically an input and output board where you have all the external connections even to switch on and off your gripper which you can program through your standard teach pendant. So that program operates this all inputs are output. So one of the brackets is fitted here that is connected, and it goes somewhere over here I will show you. So you see, it is available made available here. So this is the place where you see this wire is coming. So from here, right from here, it comes, and finally it goes to that board, got it. So, that is the output input and output terminal. Basically, this is the input and output terminal where you can connect even the gripper, which I am able to operate from my program or through my teach pendant, which is basically attached here.

And what you see at the bottom is an electronic unit which is also equivalent to the SMPS standard; it is an industrial SMPS which converts the AC signal to different control signals, control electricity. It is in the range of 0 to 24 volts, sometimes 5 volts and even 12 volts. So, all those are made available through this SMPS, got it? Now, a

big thing which is hanging over here is your inverter. It is your inverter, and it has a ducting fan, which actually cools it most of the time; all the time, it keeps running. So, this is your inverter as soon as you switch on this motor your motor, your robot starts working, and this inverter comes into the picture, and then it actually starts the fan and all the inverting functions. And this is also having a connection so that it can be controlled via your controller.

So, overall, it is there, and if I get further inside to this, I will show you yes. So, this is a closer look at the for the all those stuff which I have marked here. So from here, you see this is your if you lock this door from external switch what you were able to control actually it was switching this switch. So this is all the boards which are there closely, and this is your inverter layout with the fan and the input and output system is controlled here. It is your servo pack. Now, you can see much more clearly. So, these are the six actuators, which were controlled servo motors, which were controlled and actually powered from here; this is the servo pack.

Now, it is the teach pendant. It looks very much like a handheld PC or just like your mobile phone, and it has many similar switches that you can find. I will zoom it inside so that you can see from the top. So, first and foremost, it has a switch which is here which is known as a mode changing switch. So, it has various modes of operation. If this switch is here, it can be controlled from any external signal. It is for the normal running of this robot.

If it is here, you can normally operate this robot, or if it is here, you can do some teaching operations you can teach your robot. You can take your robot to teach that place, and later on, if you have recorded that place, you can make your robot go to those specific positions that you have taught. It is the run button. Normally, it is just a signal which is green in color, so it shows the status if the robot is started. It is for the hold one. The robot is on hold; it is here. It is a very, very important signal; if anything goes wrong, you can press that button. It is also known as a mushroom start-stop button. So, once you have pressed it, everything goes to a halt means wherever that robot is there, it will be there forever as long as you do not take it out from the halt position. So, it has to be rotated in order to un-switch this one. So, if it is switched on by pressing it, you can release it by rotating it like this. So, these are a few important switches I am showing you for a Yashkava GP12 robot. The system is very, very similar if you take an IKuka robot or an ABB robot. So, things are not very different even for those robots.

So, just like your mobile phone, if you have played any video game or something like that. So, this is your menu operating keys. So, left, right, top and bottom, you can drive your menu from here and select one of them right. If you see x plus, x minus, y plus, y minus. These are some Cartesian motion if at all you want to do. So, that can directly be done. Cartesian motion can be done directly from here. So, along the x-axis, along the y axis and the z-axis, all those you can make here and then apart from those x pluses, x minus, you also see it is written as S- over here, S+, L-, L+, U-, U+ and additionally you have r plus r minus different switches. So, if all robots are moving in the joint at the joint level, you can control all the six axes in those joints directly using these buttons, okay? And what is this? It is an external axis. If it is fitted, you can control it like a turntable, right? So, similar is other robots, they also have similar buttons, if you have seen them. So, this is to change the mode you can either go in joint mode or a coordinate mode. Select the tool right.

Page control: paging control can be done here. So, a few things are very, very easy to understand just by looking at the icon which is placed on top of this, and this is a numeric keypad very, very commonly used to enter some values if you want. You must be wondering where my keyboard is, after all. So, the keyboard is displayed on top of this UI, which is here. The keyboard is displaced immediately as you press the key. It comes here. So, that you can key in different text if at all it is necessary.

Normally, in the case of an industrial robot that is not always used, it is not always required the way it is designed. It is very user friendly so that any apprentice any floor worker can even program it right. So, it is very, very user-friendly. So yes, it looks almost like it has all the editing features which are here; all the editing is shift, delete, enter, and modify. So, all standard modifying features are here, right? And robot status is shown here. All you have is a welding attachment also, which is shown here right? So this is how a teach pendant is and it has a handle thing, so it has a very good handle to hold it firmly with your hand so that you can program it very perfectly, and this is the wire which goes below.

Now, looking from the back, it has various other things which are here. So yes, these are some of the external pen drives; you can insert them here so that you can copy a code and you can copy it to your controller. Pen drive, some IOs, and temporary IOs can be fitted here, and what you see here is just next to your hand gripper from where you are gripping it. So, this is the switch. From here, it is not very easy to display it, but yes, this is a three-state switch, so if you hold it, it is off; if you press it is on and if you further press it is again off. What does it mean, actually? It is a panic state switch so that when you feel something is in danger, you can pull your hand sharply, and it will be off only. So, by default, it is off even if you throw it off; even if you hold it very firmly, it is off.

So, in order to keep this status ON, the servo is ON all the time; this is the indication that the servo is on, so if it is on means you have gradually pressed it. So, this is a very interesting switch, which is there. Sometimes, in the case of many other robots, you have two of them, so you have here, and you may also be having here. So, this is what it looks like externally. So, it is a very, very beautiful tool to program your robot.

So now, that you have seen the controller and various accessories. So, all things that you have seen here is a controller which is normally just like an industrial PC. It is a controller, which is a PC which has some standard real-time operating system. VxWorks may be a Windows CE, Windows Embedded, or Windows IOT version. These types of real-time OSS are there, or in this case, it is a proprietary embedded operating system which can be there right and it has a servo drive that you have seen. A servo drive is the six things that I have shown you that individually control the servo motors, which are there. A backup battery is there. So, in a few cases, you also find a small battery sitting inside this type of controller.

What happens if at all you see a power failure? It does not go off immediately. It safely shuts down the system so that nothing wrong goes on, and then it safely shuts down your PC so that when you switch it on, it remembers where it was then. So, in that case, your system is very, very safe, so it has a battery backup just like your standard UPS, so it is there. Input and output modules you have seen for grippers for handling sensors to know the state of a gripper also. Let us say that it is a very small sensor which is required to run the system right. So, if you have a gripper, you should know whether it is closed or if it is open. Suppose one of your joints reaches its limit. So, you should know it has reached its limit. Now, you have to stop it. So that is also a kind of sensor which is necessary to run your robot. So that also is a sensor.

There can be external sensors also. There are safety circuits which are normally required again to run the system to implement various industrial standards. This safety circuit is a prerequisite to make it friendly and then you saw some power systems which were there. A control power system is there. Converting AC to DC and DC back to AC that variable frequency drive and those kinds of things. So, those were the power systems that were

there inside. It has some cable connectors to connect your robot and data communication wire. It is again a very, very important thing. You may have some standard industrial protocols like Profiet, DeviceNet, Profitbus, and EtherCat. These are some industrial ways of communicating things, just like your ethernet. They are kind of ethernets only with which you can communicate to remote devices which are connected to the robot, or the signal may be coming from some other robots or may be from a sensor which is sitting very, very far apart. So, this is all about the controller, if you see.

That is all; I think by now you have got to know what makes a robot. What thing that goes into the robot? So, in the next lecture, we will be covering the technical specifications of industrial robots. So, how do you define different parameters which actually with which you can understand how my robot will perform? What are the capabilities of my system? So, those things I will be covering with in my next lecture that is all thanks a lot.