**NPTEL Online Certification Course**
**Industrial Robotics: Theories for Implementation**
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**Week: 01**
**Lecture: 01**

**Introduction to Industrial Robots**

## Introduction to Industrial Robots
### Overview of this lecture

1. What is a Robot? and What are Industrial Robots?
2. Timeline for the development of Industrial Robot.
3. Applications of Industrial Robots.

Hello and welcome to the course Industrial Robotics: Theories for Implementation. In today's class, we'll discuss Industrial Robots. In general, what is a Robot? So, what is a Robot? What are Industrial Robots? How is it different from any other robots that you see? Timeline for the development of industrial robots we will discuss. How has it evolved over the years? And we will also see different applications of industrial robots.

## What is a ROBOT? and What are Industrial Robot?

▶ **Robot** is an automatically operated machine that replaces human effort with/without any resemblance to human.
  → They are usually programmable through a computer and can carry our a complex series of tasks automatically.

▶ **Industrial Robot** are used for manufacturing in the Industry and are capable of movement on three or more axes.

▶ With various attachments to its end-effector it has a potential to be used for all *Dull, Dirty, Dangerous, Difficult* and *Dear* tasks.

**Figure:** FANUC $M - 2000iA$, Payload: $2300kg$
Repeatability: $0.18mm$, Reach: $3734mm$

So yes, let us start. So, what is a robot? Robot: Many definitions exist over the internet and in various textbooks. But this is one of the most common ones, which is a superset of all those definitions that I found. So, it says the robot is an automatically operated machine that replaces human effort with or without any resemblance to humans, not like star movies that you see. It looks very much like a human, and they are Superman-like, and they can do they have too many capabilities. Industrial Robots are not like that.

They are very much limited in their function, but they are made to do some specific task, and they can do it now and then, frequently and round the clock 24/7. So, this is a further subset of the definition. They are usually programmable through a computer and can carry out a complex series of tasks automatically. Once they are programmed for any complex series of tasks, you will also see in the application videos that I will show you now. It can perform very intricate tasks. We will see and then once it is programmed, it can repeatedly keep on doing it throughout every car that comes on the assembly line or any other thing.

Industrial robots are used for manufacturing in the industry and are capable of movement on three or more axes. We will talk about the axis very much in detail while we will be discussing kinematics in this course. So, with all the attachments to the end-effector, the end-effector is something that is right at the end tip of the arm, which is there that holds the tool. So that tool can be a welding tool, that tool can be a glueing tool, polishing, buffing, grinding, or anything like that. So, with that end effector attached to the robot, it has the potential to do all sorts of dirty tasks, dull tasks, dangerous, difficult, or a dear task. I will tell you, dull tasks are something which you have to keep on doing for the whole day regular person, who are not trained to do them, will take quite a lot of breaks in between because they cannot do it right. It is the problem with these types of tasks, this

is very monotonous in that sense.

Dirty tasks like cleaning a garbage tank. Manually doing that task is a very dirty task, and is sometimes hazardous also, so that is a dirty task, and sometimes it is a dangerous task. Let's say you have to do some navigation in an area that is a radioactive zone. You have to find out, let us say, radioactivity in different parts of that region. So, that is very dangerous, right? You are exposed to radioactivity in that region. So, that is one of the dangerous tasks. There are many such which are there in the industry within the shop floor also, right? And sometimes their jobs are very difficult, like material handling, you see.

It is sometimes very, very heavy also. It goes up to a ton that is to be displaced now and then. So, that is a difficult task, and there is a special task, which is a dear task, right? A dear task is a task which we want to be done by the robot. Why? Because we want to do it very, very precisely irrespective of the cost, whether it is dull, dirty, dangerous or difficult or not. We want to do it by a robot because we want to do it very, very precisely every time, and it may be a very expensive thing, right? If you do something wrong with that, a huge amount of money is at stake, and that can go away, right? So yes, these are some of the tasks in which industrial robots are applied, okay? So here in this figure you see this is a huge payload capacity robot.

It is one of the highest in its capacity. It is a FANUC M-2000iA robot with a payload of something around 2300 kg, and repeatability is as good as 0.18 mm. We will talk about repeatability, how it is defined and all in further modules of this course also. So, the maximum reach is something around 3.7 metres here. So, this is one of the biggest one of its kind. This is an arm, right?

# Timeline of Industrial Robot and its Evolution

- ▶ The first stationary industrial robot was the programmable *Unimate*.
- ▶ Invented in 1954 by the American engineer George Devol.
- ▶ Developed by *Unimation Inc.*, a company founded in 1956 by American engineer Joseph Engelberger.
- ▶ First prototype was introduced in 1959 at General Motors Corporation at its die-casting factory in Trenton, New Jersey.
- ▶ World's first production-line *serial robot* was delivered to GM factory in 1961 by *Condec Corporation* (an acquisition of Unimation).
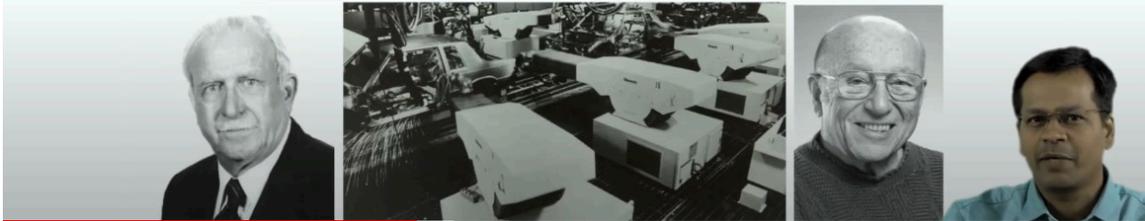


So yes, we will now talk about the timeline of how the industrial robot has evolved over the years. The first industrial robot is a Unimate. Unimate robot is the name given to that robot. So, this was a typical 4-degree-of-freedom robot where it has a workspace which is very much like a spherical workspace till the tip before the last end effector. So, it can do some sort of role. It has one angle like this, and it can rotate like this, right? Two rotation axes, and one of them was prismatic. So, that can increase the radius of this sphere, right? And at the end, there was one gripper which could do this motion, right? Pitch motion, rather. So that is one of the oldest robots, which evolved and then took over the industry and later on for various other purposes also.

So, this was invented in 1954 by an American engineer known as George Devel, right? He invented this, and later on, the development of Unimation Inc. Corporation basically took over this robot, and they started making it commercially. It was founded by an American engineer, Joseph Angel Berger, in 1956, who started making it commercial, and the prototype was introduced in 1959 at General Motors Corporation at its die-casting factory in Taunton, New Jersey. It was a die-casting factory where it was first used. Later on, the world's first production line, production line means you had a good number of robots which are there in a single assembly line, and each robot had a specific task to do. And that was implemented the first time again in the General Motors factory in 1961  by Kondek Corporation.

It was an acquisition of Unimation Inc. These are the pictures of that assembly line and these great men.

So yes, now we will see some of the applications of industrial robots. So, here, this is one of the very commonly used industrial robots, which is known as an arc welding robot, right?
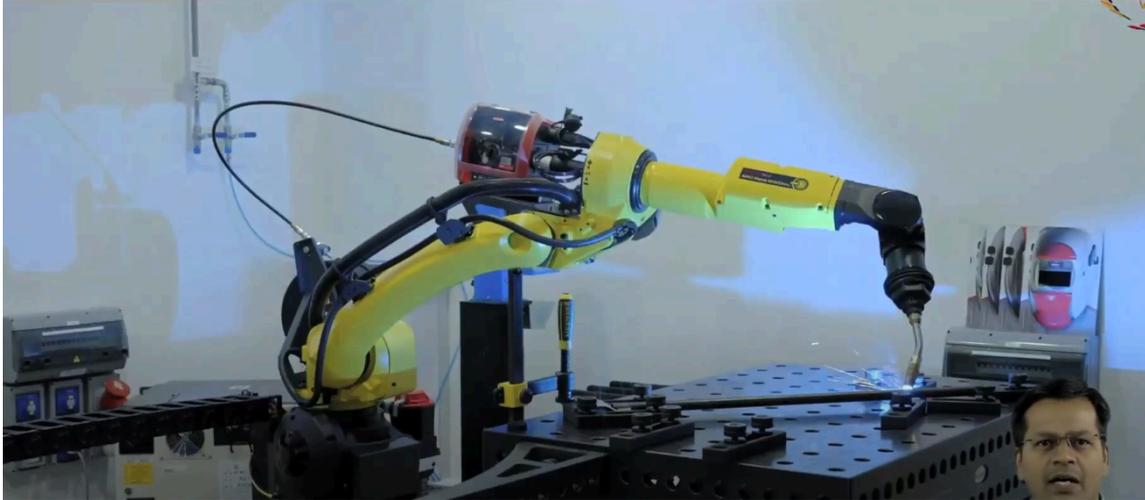


It is one of the most demanding tasks in the industry, and the robot is applied for, robots are applied to do operations very often and the one which you are seeing here is an arc welding operation. Here, the robot end-effector is mounted with a MIG welding tool, where the robot wire is fed automatically at a constant rate. You see, such a nice outcome. The welding path is taught manually and can be controlled automatically using sensor inputs and a predefined geometry.



See, it is a spot welding application, which is yet another very common in the industry where robots are used. Here, the robot is mounted with a spot welding gun. In this case, the object is mounted and the robot is taught all around to go and do spot welding operations. It can be otherwise also when the electrode is stationary and the object is moving, right? It is a very common operation.
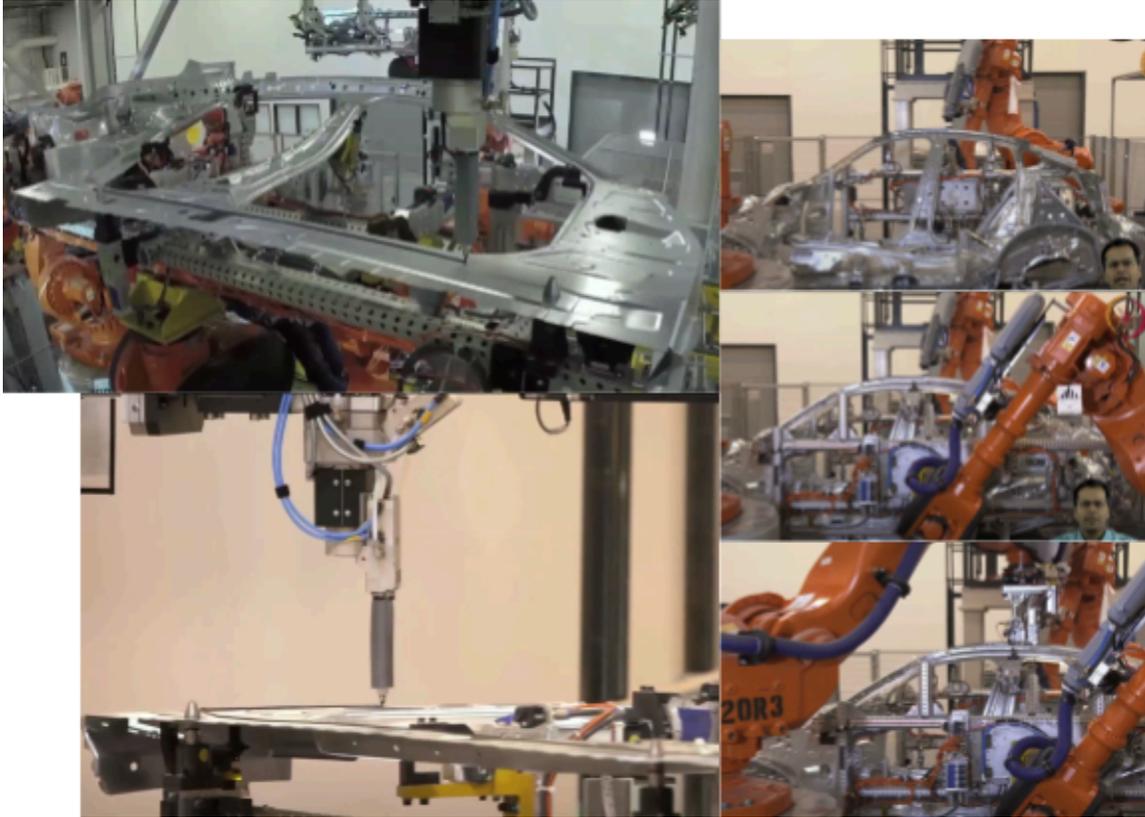
It is known as a glueing operation, where the glueing extruder gives this field, and the path moves all around. And that path is well taught sometimes, and sometimes it is done with the sensors. The geometry and the direction of everything is pre-taught. Now you see, those parts are getting assembled by the robot from one side after glueing. So, that is the adhesive sealant that was put in, and on both sides, you see the covers are being put by two different huge robots, and there is yet another robot that puts the top assembly from the top. That is a car which is being built. It is a body shop.

It is the assembly line where you see spot welding, glueing tasks, assembling tasks, and various other tasks being done by multiple robots. You see, one by one. Hundreds of them are there in a single assembly line. Quite interesting, and it keeps on doing it the whole day long. So, each robot has a pre-assigned task programmed to do it.



See, this is a regular car dashboard, and yes it is picked up from here, and then this robot is going. It is a KUKA robot. I think it is a Mercedes robot, a Mercedes car. It just puts in just like a human, and gracefully, it puts to a very good precision to its place and will gradually leave it, come out just like without avoiding all the collision and it will come out. This program is done manually, sometimes using sensors.

Again, a similar front glass of a car is being placed. Yes, again, a similar glueing operation is being done here, you see. It is put to the car front. Yes, it is so nicely placed and accurately placed, and if another car comes, it will pick up another thing.



It is the grinding task, which is again very common in the industry. Different tools are loaded on top of the robot in the front end of it. In the end effector and each one perform its task. Again, different tools of different sizes and different abrasive sizes also may be used. So, that is now inserted into a different location, it does the grinding task. In this type of robot, normally, it is also fitted with a force sensor, it can feel the forces so that it can have a constant force all over and do uniform grinding on the polishing operation. It is the type of deburring, and finally, polishing will be done. So, each process requires a different tool to be fitted at the top of the robot, and each one does its job. Finally, you get

to see a uniform finish thing. You see, it is doing so nicely, just like humans, because it is taught by humans. See, a nicely looking uniform surface finish.
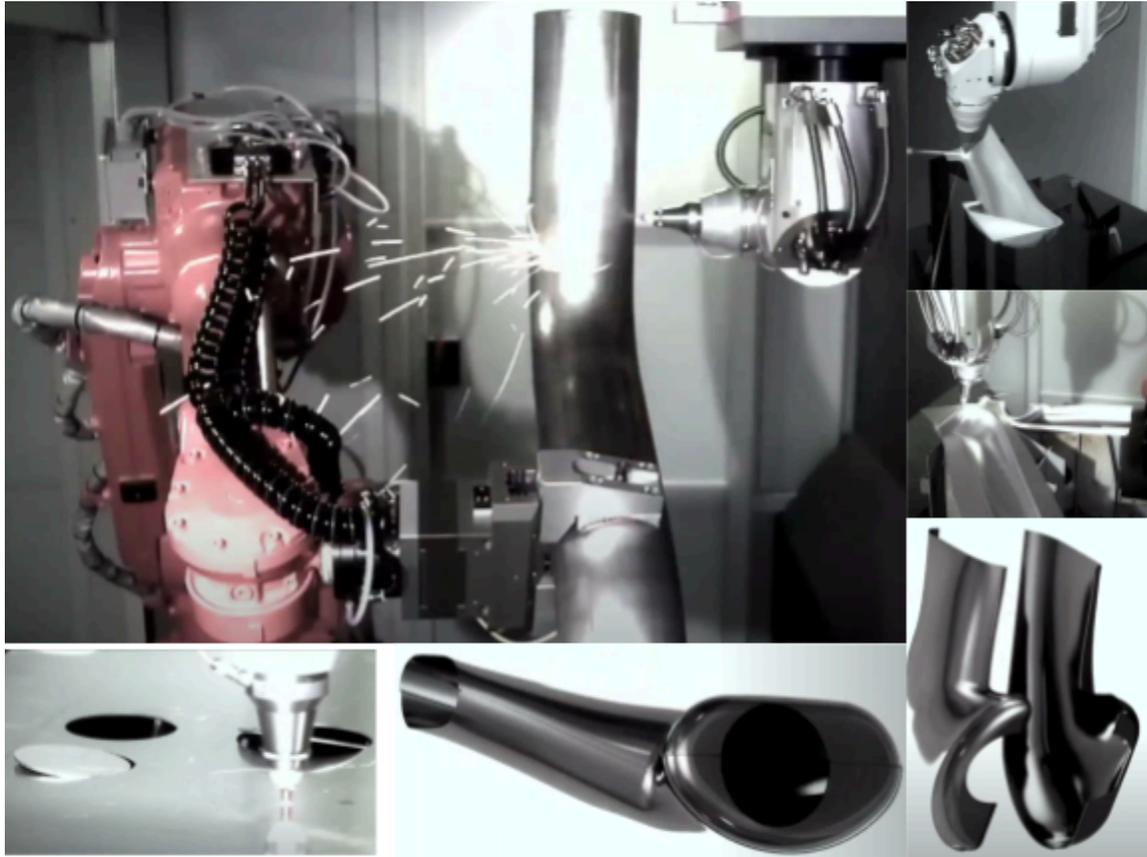


It is one of the most wonderful tasks you will see, you know. You see a silencer probably or sometimes a rack tube, so it has been cut by laser. So, laser cutting is a very good operation that is done because it is hazardous also. Humans cannot go inside the chamber where the laser is in operation. Powerful lasers are there. It is precisely cutting the task, see uniformly orienting all over the tube, and it is cutting a profile, not just a circular shape, right? Looks like a silencer of a car, maybe, yes. Another similar part is very profiling in this kind. It nicely orients and cuts, so every time, the cutting angle is maintained because the CAD is inserted into the geometry of that simulation tool, and finally, offline programming is done, and that is fed to the robot. So it can be assembled later on like this. It is another very, very common, and it is a hazardous task also.

It is a painting robot. Different robots work just like humans. You see, these are mirrored robots. It looks like a mirrored robot. From both sides, it is uniformly painted. One of the robots is just holding from the top. It will gradually close it also. And some of the robots are opening the door and still painting is being done by the robot. See, it can orient so nicely; all the sides are doing so gradually and nicely without hitting anything. You see, the robot itself is also shielded well so that paint should not destroy the electronics which are there in the robot.



It is a material-handling task. You see, huge metals are picked up by the robot from different places and n number of robots are there in a single workspace. They are arranging them, and they are putting them from one place to the other. Each robot has a

pre-assigned task, which is programmed before and one of them is hanging on top of a moving conveyor. From the top, you can see very clearly different robots are doing different jobs. It is a heavy material handling.



It is one of the tasks where the robot is doing some PCB, pre-assembled PCB assembly to a system, maybe, right? So, each electromechanical part is placed one by one, and they are put on top of the PCB, and finally, they will create an electromechanical assembly, right? The electronic industry has a specific requirement for precise robots when sometimes you don't need to roll and pitch. You just need to pick it up and place it at a place, right? So, it has a different gripper. One of them will hold the chip, and the other one will hold something else. So, the same robot can have different tools at its end.



Now you see, this operation is in particular known as a palletising operation in the industry where various objects of a similar kind are stacked together in a carton which can be placed on a conveyor, finally can be loaded onto a truck, and that is dispatched. So, this is a very very common task in the food and beverage industry like that, right? You see again, similar multiple robots are handling similar packets, and they are putting

on the conveyor. One of them is taking out of the conveyor and putting it onto a different container that is further carried off by different industrial automation systems. So, precisely locating this carton in front of the robot is done by an automation system which has various other sensors which are integrated into the robot to give it well feedback that yes carton has now arrived here, now you have to pick it up, now you have to place it.
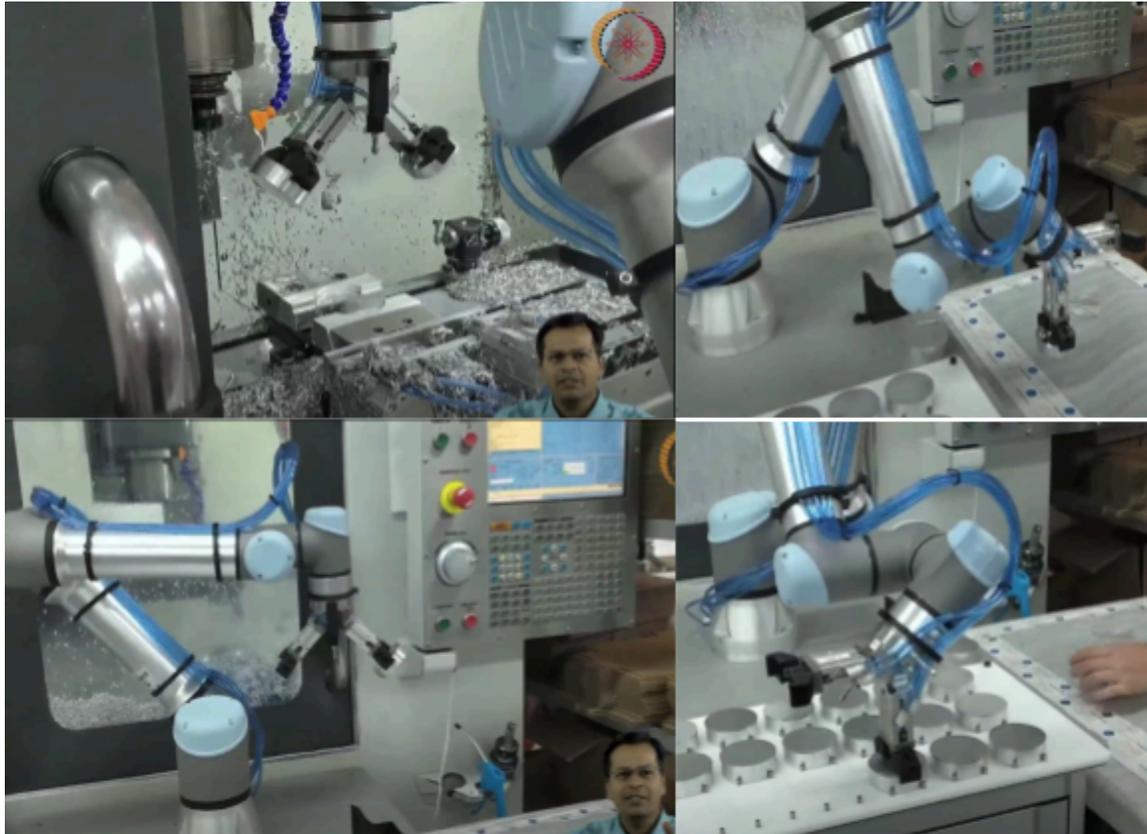


Now you will see a different kind of operation. It has been a very long time since it was a manual task. It is known as a machine-tending operation. You see, this robot is now taking up a finished part, which is machined already by the CNC machine, and it is placing a raw part inside, taking out the machine component from inside. So, the whole day, it will keep on doing that, and the machine will keep on. So, machines and robots are talking to each other. Yes, I have finished my task, now you start your job. It will press the button, it will come back and put it in front of the human which may further do something with it. It is the finished part, which has been kept outside. Now, it will pick up another raw material and be ready to put it inside the machine. So, the cycle goes on.

It is a very dirty task. I have just talked about this. Sometimes hazardous also. It is garbage segregation. It is off the industry most of the time. So, industrial robots are not just used in industry because they are very versatile robots which can be programmed to do various other tasks. So, it is used in the industry also like this. It is garbage segregation. It also includes a lot of intelligence.



It is a very very special task when the robot is doing hair transplants, assisting doctors to do hair transplants. They work with the doctor. It is a special kind of robot nowadays which is known as a cobot. So, the doctor can precisely prepare a cartridge with all the roots of your hair in a spool, and that spool is fitted into the dispensing cartridge in front of the robot, and the robot will finally put it to the scalp. Long-sitting operations, when a

patient has to do, it may also be painful. It looks very scary over here why somebody should go for certain operations where robots are doing something. It takes time to build confidence when a robot is in front of you instead of a physical doctor.



It is yet another interesting application of a robot when a robot is used to do some movie shooting. So huge cars that you see flying all around in the air in different movies nowadays, those cars actually fly off, not just by CGI techniques. It is sometimes very, very physical like this. Two robots are just moving this after the explosion which is simulated here with some sort of sprinklers which was sprayed. It is from the movie which is Fast and Furious, done by Universal Studios.



It is an amusement task. You see when a robot can make you feel a huge acceleration. It can move like anything at different angles, and sometimes the rider also wears a head mount device that is VR, you would say, right? And they just feel the roller coaster. It is demonstrated in one of the fairs by KUKA Robotics, and they call it a robocoaster. It is a robocoaster when a person is made to do all this. It is, again, very scary and sometimes risky also. It is not very common, though. But yes, you see now robots can take up all these tasks very easily. So, it has a lot of potential to be used even outside the

workspaces, not just industrial workspaces. It is doing various other tasks, right? So, let us go back to our slide.



So, you have just toured various industrial applications and saw industrial robots not just in the industry but also outside the industry. So, these are some of the examples that you see when material handling: picking and placing the object from one place to the other, pelletising, packaging, processing, welding, spot and arc welding you saw, surface finishing you saw, polishing, buffing, grinding, deburring, and painting task. Similar is an operation which is called spray coating, metal cutting you saw using a laser gun, glueing, adhesing, sealing, machining, drilling, etc. All these tasks are very, very common in industry. Assembling needs some special type of robot, which is known as a cobot. They do normally work with humans, right? It is a collaborative task that needs some sort of compliance. Machine tending task you saw, you saw PCB manufacturing, not just this, there are many other applications where a robot has the potential to go. We won't discuss much on them. It is medical, space, underwater, defence, agriculture, movie making and amusement that you saw.

Yes, so with this I would end this lecture here. That is all for today. Next class, we will be discussing the anatomy of industrial robots. How and what makes a robot? What are all the things that go into making a robot? Ok, thanks a lot.