·LESSON 07·

Forward and Inverse Kinematics: Application

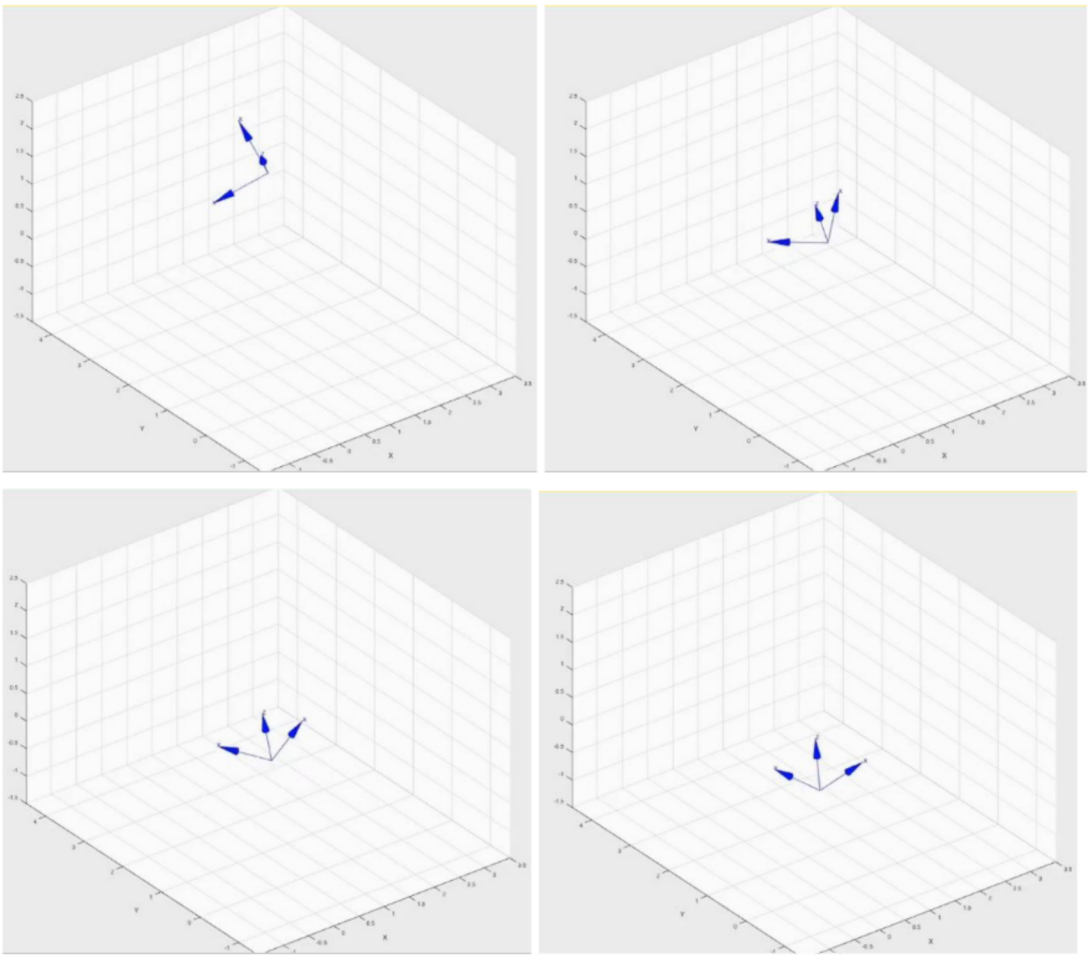
Lesson Overview

In this lesson, we shall have a look at how we can actually move a robot using joints and analyze its motion in 3 dimensions. You will learn the following:

- Trajectory interpolation
- Robot joint control
- Analyzing motion of a robotic arm in 3D

Trajectory Interpolation

Consider the problem with a robot moving from position A to position B. It's going to have to follow some kind of path, so its pose will change as a function of time and that leads to two very important concepts that we refer to as a path and a trajectory. And what we want to be able to do is to describe how the pose changes smoothly and elegantly as a function of time.



So here for instance is a small example how the pose of an object can vary as a function of time. And we see here in this three-dimensional coordinate frame, its position is changing and its orientation is changing very very smoothly. And we want to

be able to apply these kinds of techniques to general problems in robotics.

Additionally, do have a look at the following videos for a better understanding.

Paths and trajectories: https://youtu.be/y4IW2RVLZTE

1D polynomial trajectory: https://youtu.be/HqQBL6xcj4w

1D trapezoidal trajectory: https://youtu.be/3Kmlpe8kgbk

1D trajectory with via points: https://youtu.be/xg5DP1YEPv4

Multi-dimensional trajectory: https://youtu.be/ppGl3Pz2baE

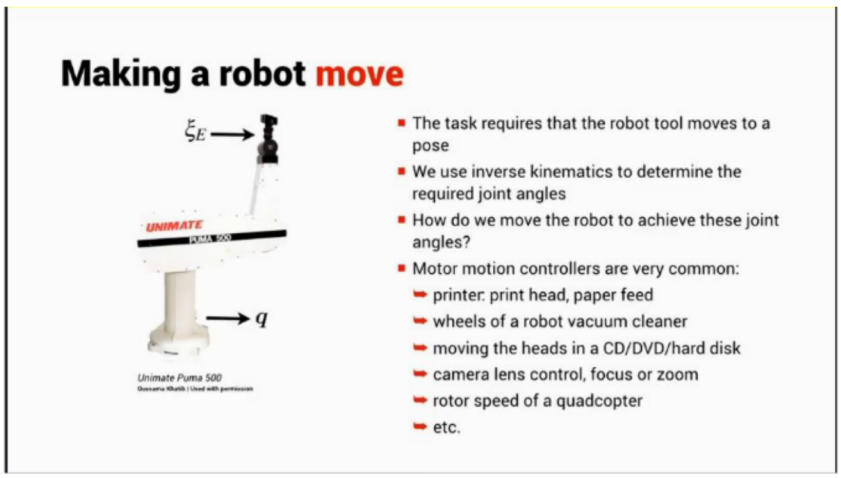
Interpolating rotation in 3D: https://youtu.be/4338NlHagjc

Interpolating pose in 3D: https://youtu.be/32m8rQ-lbuo

Robot Joint Control

In this section, we're going to talk about Robot Joint Control. That's how we actually make a robot move. It's a really important problem. So, using some of the principles that we've already learned about in this course, we have a robot here and we're going to say, "I want the robot end-effector to be at this particular pose." This is a constraint that comes from the particular task that I'm trying to do. I'm a robot arm and I want to pick up this particular object then I know the pose that the robot end-effector has to achieve.

Now, we can use the inverse kinematics to tell what should be the angles in the joints of the robot arm in order for the end of the arm to get to that particular pose.



So, we've talked about how to do this. This is the inverse kinematic problem. The challenge that we're going to talk about in this lecture is how do I actually make the joint adopt a particular angle. The joint's got a motor in it. It's got some sensors in it. So we're going to talk about the control system that makes the joint have the particular angle that we want it to have. This is the joint control problem.

Now, this business of trying to control the position of a motor to control the angle of a robot joint is a really common problem in mechatronics. There are many, many motion control systems in all sorts of things that we own that we probably don't even know that they're there. In an inkjet printer, there is a very precise motion control system that's moving the printing print head across the paper.

Another motion control system is moving the paper backwards and forwards through the printer. A robot vacuum cleaner has got a motion control system to control the speed of each of its wheels so that it moves with the appropriate velocity across the floor.

Within a hard disk drive in your computer or within a DVD drive, there is a head which reads the information off the spinning disk. It has to be positioned really precisely over the disk's surface.

These motion control systems are very, very pervasive pieces of technology in the modern world. So, what we're going to learn about today is a very particular case of a motion control system. It's a motion control system that's controlling the angle of a robot's joint.

You can go through the following videos to have a better understanding.

Robot joint control system: https://youtu.be/X3Uhk5gJnhg

Modelling and simulation of a joint control system: https://youtu.be/pLzeZ92423c

These videos are not compulsory, but you can still have a go at them.

Actuators: https://youtu.be/RDj92UzpSZY

Electric motors: https://youtu.be/vhle95IBmek

Analysing the motion of different robots

You can have a look at the following videos to understand how the robots work. MATLAB software is used to run some scripts, but don't worry, there is nothing too complicated in the videos.

Analysing the motion of a 1-joint robotic arm:

https://youtu.be/PVZb5UVahkk

Analysing the motion of a 2-joint planar robotic arm:

https://youtu.be/b89WHj6eITg

Analysing the motion of a 3-joint planar robotic arm:

https://youtu.be/b-4wvupSnlU

Analysing a robot arm that moves in 3 dimensions:

https://youtu.be/QeBPOtvqyyI

Analysing a general purpose robotic arm that moves in 3 dimensions:

https://youtu.be/Fi9w763MgSo