Course Name: INTELLIGENT FEEDBACK AND CONTROL

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Week - 04

Lecture - 27

Hello. So in this video, I'm going to summarize what we did in this in these four weeks. First of all, what we had the flow in the understanding of the systems and how the controllers applied on it. We categorized the system in dynamical systems and non-dynamical systems. We understood that the control problem is for the dynamical systems.

And then we looked into, okay, categorizing it into linear and nonlinear system. The entire classical theory, the transfer function theory sits on LTI system, linear time invariant systems. Whereas the nonlinear systems theory also requires some understanding of the control linear systems. We can always consider operating range for controlling the nonlinear system and possibilities that within that operating range, the nonlinear system behavior is actually pretty much linear. And so look forward for resorting to LTI system methods itself for controlling the system.

We also looked into multiple input and multiple output systems, large scale systems, which has very high number of states and so on. In all this, the practical approach, the emphasis was on simplifying the model or limit the operating range and then design the PID controls. The idea here is to always consider simplistic methods, because finally, these simplistic methods are very easy to implement. The first point. The second is when these are easy to implement, it can be easily understood.

Then we would be able to tune these control parameters very easily and the tuning of the control parameters will also have some systematic approach. So these systematic approach for the PID control tuning have been very much studied and that's what we have looked into. The entire emphasis here was to simplify the system, whether it's a MIMO system, whether it's a large scale system, try reducing it, what is needed and try looking into what the control objective to be set for. In order to control these simplified models we looked into control structures we understood the difference between feedforward and the feedback controls, what is possible with feedback control and what is possible with feedforward control, under what conditions we need feedforward and under what conditions we need feedback. Does at any point of time, the control objective needs both the control techniques, feedforward as well as feedback.

We emphasized all the model reduction methods or simplified methods. Approximate methods for simplifying the higher order systems. We looked into considering reducing it to a first order or a second order system. Because most of the times these systems have their dominant behavior as first order and second order system. And that's what we said, that if I have these first order and second order systems, so then PID control is a very good choice.

Of course, the PID control methods will not satisfy all kinds of control objectives. So we know now that PID control will be able to satisfy these kinds of control objectives given this kind of a system. And that's why we should first try giving a control methodology as PID. We looked into PID tuning methods. These tuning methods could be based on classical tunings like Ziegler-Nichols, Cohen-Coon methods and so on.

The newer techniques, which are learning based methods, where I am unable to find the input-output relationship, or the model representation of a system is unknown. Or it is a very, very complex behavior that it is having that I am unable to represent in the form of the mathematical equations. The physics of the system is tough to understand. So then we will resort to these data-driven methods where I will have certain observations and based on which we will provide the actions on it. Okay.

So in the entire journey, the idea is very clear that we will be able to apply PID control if we know whether PID control will be beneficial for certain cases. And those cases we have identified that, okay, these kinds of control objectives can be satisfied but not all.

Right. So in certain control applications, instead of making very very tough or difficult control objectives or multiple control objectives to be set, we can always the practical world is not so difficult and we can always simplify those control objectives by prioritizing it. Now, when we are prioritizing it, we will be able to then say, okay, these prioritized control objectives, am I able to solve it with the help of PID control is what the idea being pursued in these four weeks.

At the same time, presenting the problem such that PID control method is going to be beneficial or we are able to simplify the control objectives being set. One great example that we took is about this inverted pendulum on the cart. And then we represented the reward function such that the inverted pendulum comes to the theta equal to zero position. But while forming the reward function, we had to consider reward equals minus theta upon pi minus one whole square. And a few other terms were also there, theta dot related and then tau related terms were also there.

So in this case, we had considered that this particular term is within the range minus 1 and plus 1. All right. So when we had to consider this particular range, it was a good idea to consider making the mapping of theta equal to 0 to theta equal to pi. So one can always consider that if this is my cart and my upright position is this, I represent instead of this axis, I represent my system with respect to the vertical down, which is like theta representation is now theta equal to zero here and theta equal to pi here. So, then the theta values are between minus pi by 2 to plus pi by 2, but at the same time it is in this range instead of this range.

All right. Right. So, the representation, normalization that makes the idea of running the PID control or a simpler form of controls working in the practical environment. I hope you enjoyed the course. Thank you.