非線性控制第八章作業

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Consider the following 2nd order nonlinear system:



where  is control signal;  and  are uncertain parameters with the condition



Our goal is to design sliding mode control that makes the system above satisfies Lyapunov stable.

Assume the sliding surface as



Remark. Sliding surface is the key to sliding control. It’s a curve or a surface in the phase space which represents the final state for the control system.

(a)

We first take the derivative of :



Since there exist uncertain parameters

 and ,

we can express the control law  as



where  can be obtained by assuming . The reason we do this is because  is the “average” control law which maintains a balance system when the real parameters  are at their average point .

Note that the definition of the sign function is



Therefore, we have



The control law then becomes



Substituting  into  gives



Afterwards, to ensure the condition  can be satisfied under this control law, we simplify the equation to obtain  where .



We then have





Let , we can successfully prove that the control law



where  and  can ensure  which will make this system Lyapunov stable.

(b)

Now, we use Matlab to ensure the accuracy of the sliding mode control.

Let , so  will be a random constant within the range of .



In the figure, with the initial point , we can see that the phase space will eventually converge to a surface which is .

To make sure that the initial point won’t affect the system to converge to the sliding surface, I also tried a different initial point  which lies on the left side of the surface.

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In this figure, we can see more clearly that it doesn’t matter where the initial points are placed, they all ended up on the sliding surface.

However, note that in the two figures above, the system won’t stay on the surface at all times once it gets to the surface, mainly due to the uncertain parameters. When the state kind of flows away from the surface because of the uncertainties, the control will once again pull it back to the surface and this situation goes on and on. That’s why there exists the “vibration” or “jumping effect” near the surface and this situation becomes less obvious when it’s closer to the origin.

(c)

We now let  to observe how this will change the phase space of the system.



In the figure, the initial point  is chosen once again, and we can see that the system will converge to the same sliding surface as before. We can easily notice that the vibration is more severe than when setting .

This is because when we apply  for the uncertain parameters , we gave them “more space” which led to a more uncertain result here, especially after the system converges to the sliding surface.

With that being said, I decided to expand the range to  just to see whether my inference is correct and how much the range of the uncertain parameters actually affect the vibration/jumping effect.



In this figure, we can see that the value of range of the uncertain parameters  and  will certainly make a difference when it comes to causing the vibration/jumping effect near the sliding surface.

Aside from the range of the uncertain parameters, there are several other reasons that cause the vibration/jumping effect more obvious as well. These include the measurement error, calculation time delay and so on.