Wireless Feedback Control

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Overview
The topic Networked control system (NCS) has drawn broad interest within the control system community recently. It takes the effects of non-ideal communication channels into consideration when applying system analysis or synthesis. There are many topics concentrating on different aspects of the channel effects, e.g. delay, quantization, signal-to-noise (SNR) constraint, disturbance, packet drop, etc.

In this project we will build a wireless channel and an experimental platform to perform networked control. This platform will involve some typical features of channel effects, therefore different networked control algorithms can be tested with this platform.

Inverted Pendulum is used as the control object and APC220 Radio Data Module is used for the wireless data transmission.

System Modeling and Controller Design
By using Newton’s Law to model the system and linearize the model around the operating point, we obtained the transfer function of the plant:

\[ P(s) = \frac{1}{s^2 + 100s + 2500} \]

To stabilize the plant with a PID controller, after selecting the poles and implementing the pole-placement algorithm, we obtained the PID controller with best performance:

\[ C(s) = \frac{-0.063 - 1.94s}{2.0735 + 0.025s} \]

Platform Development
The platform development mainly focuses on the following three parts:

- Wireless Channel
- Hardware Design
- User Interface

The designed user interface has the following functions:

- Adjust sample time
- Adjust quantization level
- Observe the plot
- Select the sampling model (created with hardware wireless channel or the delay)
- Select the controller to use

Wireless Feedback Control Performance
With the platform built, we can perform the wireless feedback control and observe the performance.

Figure 4 shows the performance of the system when sample rate is 40 ms and transmission rate of wireless channel is 19200 bps. Due to the large delay, there is an oscillation on the angle of the inverted pendulum. This is because the response of the controller cannot be immediately transmitted to the plant.

Discussion and Conclusion
- Avoid using the wireless channel in the closed-loop
- Sample rate could be smaller when delay is large
- Future work on isolation of wireless transmission devices is needed
- Future work on generality of interfacing with hardware is needed