Control of a Ball-Beam System

(Networked Control System/Combined Feed-forward and Feedback Control/Dual Motor Control)

Background

As a typical control system, the control of the ball-beam system is excellent in testing and evaluating different control methods. The fundamental principles within this control system can be found in many industrial applications, such as precise position control in production line. In AUE, A set of ball-beam systems have been developed in recent years, such as the single motor B&B system as shown in Fig.1 (left) and the dual motor B&B system as shown in Fig.1 (right). The main idea of this kind of control problem is that: a metal ball is placed on a metal beam, where it is allowed to roll with one-degree of freedom along the beam due to the gravity. A motor or two motors is/are attached to the beam at the central/two-ends position such that the beam can be driven and turned by some proper angle. A controller to the motor(s) needs to be designed so that the ball's position can be manipulated at some expected position.

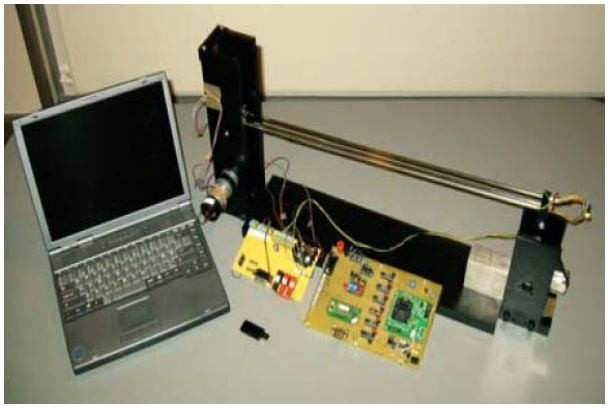

Fig.1 AUE Ball-Beam Systems

Objective

The objective of this project is to develop a control system for the dual motor setup. Distinguishing with previous projects worked on this setup, this project needs to explicitly take the external disturbance to the system due to the weight of the beam and ball into consideration. Thereby, besides designing a feedback control system, a kind of feedforward controller, for example, as shown in Fig.2, is also expected to be developed in order to decoupling the disturbance effect. The project contents could include:

- Hardware development/improvements, including the drivers for sensors and actuators, plus the MSP as well
- Mathematical modeling and Matlab Simulation of the mechanic subsystem and the electronic subsystems including the model of DC-motor(s);
- System analysis and control Design, including feedback and feedforward controllers;
- System testing and analysis;
- Validation and comparison if more than one kind of controllers is developed.

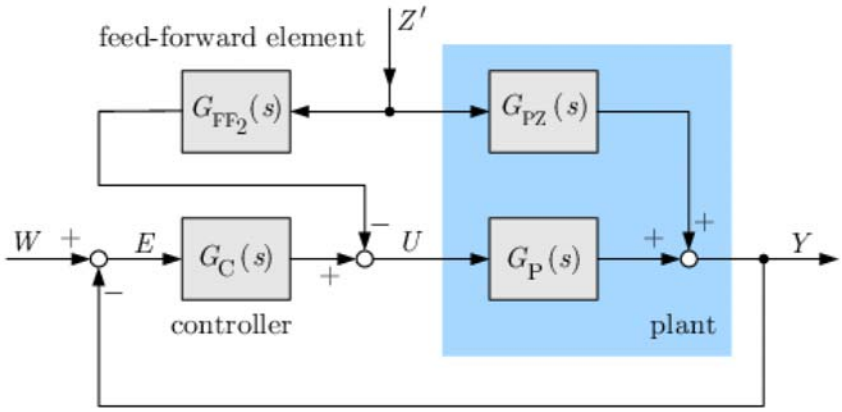

Fig.2 Schematic diagram of a combined feed-forward and feedback control system with known disturbance

Remarks

- There is also the possibility to use the single motor setup for this project. The difference using the single motor setup is that the external disturbance only due to the weight of the ball (if a heavy ball is used comparing the weight of the beam), and it generates a time-varying torque to the motor due to the time-varying position of the ball. While for the dual motor setup, the torque due to the weight of the ball and beam can be approximated as constant. In general to say, the consideration of using single motor setup is more challenging due to its time-varying feature.
- Another kind of challenging could be to extend the developed control system into a Networked Control System (NCS), which means a control system wherein the control loops are closed through a real-time network. As shown in Fig.2 the feature of an NCS is that control and feedback signals are exchanged among the system's components in the form of information packages through a network. Then, what kind of network, how about communication protocols, real-time information collection and efficient processing of sensors data and so on, need to be explored and handled in the project, besides the development of standard feedback control system. Two typical challenging issues of NCS are: the additional time delays in control loops and possibility of packages loss.

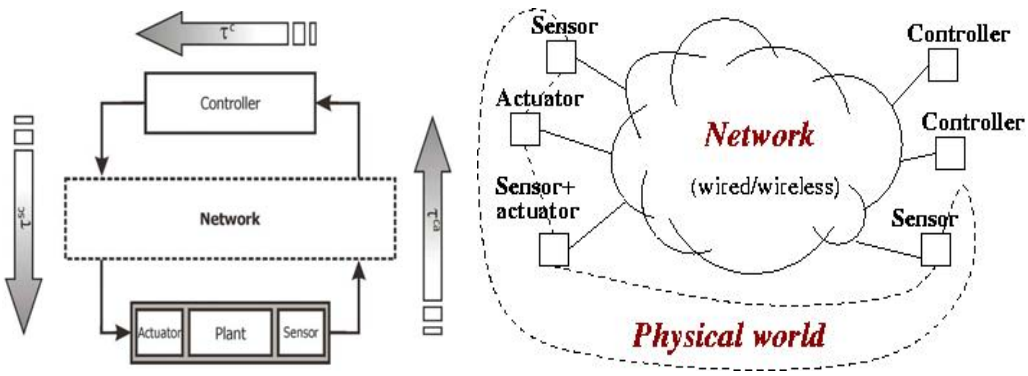

Fig.2 Schematic Diagram of Networked Control System

Resources

- The main hardware system is available at AUE E-Laboratory;
- Some previous project reports.

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