Institute of FIeld roBOtics (FIBO)

A Cradle of Future Leaders in Robotics

Nonlinear Control of a Crane system

Investigator: Nirut Naksuk

This research presents an Input-Output Feedback Linearization method (IOFL) which is used to transform nonlinear state equations of a real crane system into linear state equations. Controllers of such a crane system can be designed by using several linear approaches, *i.e.*, pole placement and linear quadratic regulator (LQR) methods. By performing feedback linearization, the system still obtains wide ranges of operating points.

As shown in the figure below, a cart is driven by the a power transmission belt that transmits power from a D.C. motor. This motor is controlled under torque commands calculated by a computer.

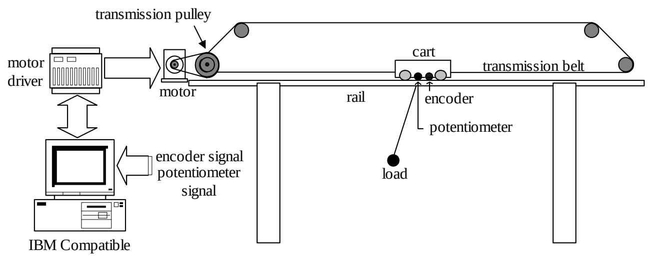
In our previous work, we implemented the state feedback strategy in order to govern the cart position and load angle, while the feedback gains were designed by the linear Quadratic Regulation (LQR) method which minimizes the summation of cart position, velocity, acceleration, load angle, angular velocity and angular acceleration errors of the crane system.

In this research, we introduce load positions as outputs of our crane system together with the effect of the coupling between the cart and load. In this case, the objective is to control the desired load position even in the presence of wind disturbance.

Some terms in our new-deried mathematical model are nonlinear. This nonlinear model must be transformed into a linear system. Transforming nonlinear systems into linear systems so called "linearization" can be implemented by several methods, *i.e.*, small approximation of the swing angle, the sine and cosine terms in the system equations reduce to angular value and one respectively, This nonlinear model can also be transformed into linear systems by using the Input-Output Feedback Linearization method (IOFL). Without any approximation of the system equations, this method allows wide ranges of operating points.

Finally, we consider the coupling between the cart and load dynamics effecting on the cart movement. Under this modification, a nonlinear mathematical model corresponding to the nonlinear dynamics of our crane system is derived using the Lagrange's Method.

Furthermore, we can design linear controllers of other complex nonlinear systems and still obtain the wide range of operating points by transforming nonlinear equations into the linear state equations. This approach is also being applied to wide verities of real applications.



King Mongkut's University of Technology Thonburi Tungkru Bangkok

Address: Suksawasd 48 Bangmod Bangkok 10140 Thailand
Tel. No. +66 (0) 24709691, 4709339 Fax +66 (0) 24709691 http://fibo.kmutt.ac.th