Robust Anti-swing of Overhead Crane by PID Control Techniques, Neural Networks and Secord-Order Sliding Mode Serial

R. Castro, M. A. Duarte, P. Cruz, A. Concha and P. Arévalo

***Abstract*— One of the most popular compensations of a crane is the neural networks technique with a PD controller. The problem of controlling the payload of the crane is the oscillation it generates when it moves at a point in the work area. To minimize the steady-state error along with unmodeled dynamics and disturbances that affect system performance, you can use a PD, but it is said that this type of control has an anticipatory characteristic, however, there is a great disadvantage that is inherent to it; since the crane's displacement response depends on the first derivative of the error, the noises in the output make the output not a smooth function and therefore causing output to act considerably, saturating the actuator and in the same way require a Integral and large derivative gain, respectively. In this paper proposes a PID control in which they are added apart from neural networks, the technique of sliding modes to decrease the oscillation of load of the overhead crane, noise and also obtain semiglobal asymptotic stability. There are compared with a neuronal PID to check the effectiveness of the proposed method.**

***Keywords*— Anti-swing, Neural Networks, Sliding mode serial.**

I. INTRODUCTION

THE cranes are intensively applied in transport and construction. A crane consists of a lifting mechanism that is suspended from a point in the support mechanism. The support mechanism moves the suspension point throughout the crane's working space, while the lifting mechanism raises and lowers the payload to deposit the load at the assigned point. For crane modeling, two approaches can be taken: model of concentrated mass and distributed mass. In the distributed mass procedure, the elevation line is modeled as a chain, and the payload assumes a concentrated mass as a boundary condition of the system [8], [1]. On the other hand, the model of the concentrated mass crane refers to a mass-free cable such as a lifting line and a concentrated mass as a payload, and has been widely used for crane modeling [2], [3]. In addition, the dynamic movement of a crane may be exposed to some unwanted phenomena such as the improper displacement of the moving object, the relatively large swing angle, and the residual swing at the point of assignment. These limitations affect the efficiency of the crane's operation and lead to time delays and high operating costs. For the problem of swing of the load becomes a problem so interesting to attack and the previous works that one have are the following ones: in [4] PID-neural networks anti-swing control was proposed to attenuate the angular movement of the crane. The authors in [5] suggest a new plan of antioscillation control for a gantry crane, by means of the elaboration of a surface and a nonlinear control that makes the states of the system remain in that surface achieving a robust system and shows a strong solidity to unmodeled uncertainties and external disturbances. In [6] an off-line trajectory planning method is proposed based on the coupling of the kinematics of a 2-D overhead crane. The performance of the proposal is tested with techniques of Lyapunov and lemmas of Barbalat along with numerical simulations and experimental results. This paper presents a new method of anti-swing control that improves the operation of the crane when the payload is exposed to external disturbances contributing to satisfactory simulation results along with the Lyapunov techniques for stability purposes.

To fullfil the objective, this work is organized as follows: Section II shows the mathematical model of the overhead crane. Section III introduces the PID anti-swing controller with neural networks and higher order sliding modes in series, to compensate for uncertainties and load swing. Section IV describes the stability. Section V the proposed strategy is applied to an overhead crane and compared with [4] . Section VI describes the conclusion and comments.

II. MATHEMATICAL MODEL OF OVERHEAD CRANE

Here arises the problem of swing of the load of a crane with parametric uncertainty. F and G can be approximated by a neural network. It proposes a control PD with techniques of robusticidad with the compensation of neural networks and sliding modes of higher order serial to decrease the swing of the load.

The dynamic of the crane is [1]

$$M(z)\ddot{z}+V\left(z,\dot{z}\right)+G(z)+F\left(\dot{z}\right)=\upsilon \qquad (1)$$

where $z\in\Re^{n}$ is the vector that determines the angular position of the crane, $M(z)\in\Re^{n\times n}$ is the matrix of Coriolis, $V\left(z,\dot{z}\right)\in\Re^{n\times n}$ is the matrix of centripetal forces and Coriolis,

R. Castro Linares, Sección de Mecatrónica, Departamento de Ingeniería Eléctrica, CINVESTAV IPN, México, rcastro@cinvestav.mx, rcastro1304@gmail.com

M. A. Duarte Mermoud, Departamento de Ingeniería Eléctrica y Centro de Tecnología Avanzada de Minas, Universidad de Chile, Chile, mduarte@ing.uchile.cl

P. Cruz Francisco, Departamento de Ingeniería Electromecánica, Instituto Tecnológico Superior de Poza Rica, México, panuncio.cruz@itspozarica.edu.mx, panucruz@gmail.com

A. Concha Sánchez, Facultad de Ingeniería Mecánica y Eléctrica, Universidad de Colima, México, aconcha@ucol.mx

P. Arévalo Bautista, Estudiante de Maestría en Ingeniería Industrial, Instituto Tecnológico Superior de Poza Rica, México, pilar.arevalo@itspozarica.edu.mx