MODELLING AND PID CONTROL DESIGN OF NONLINEAR EDUCATIONAL MODEL BALL & PLATE

A. JADLOVSKÁ, Š. JAJČIŠIN, R. LONŠČÁK

Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 042 00 Košice, Slovak Republic

Educational model Ball & Plate (by Humusoft)

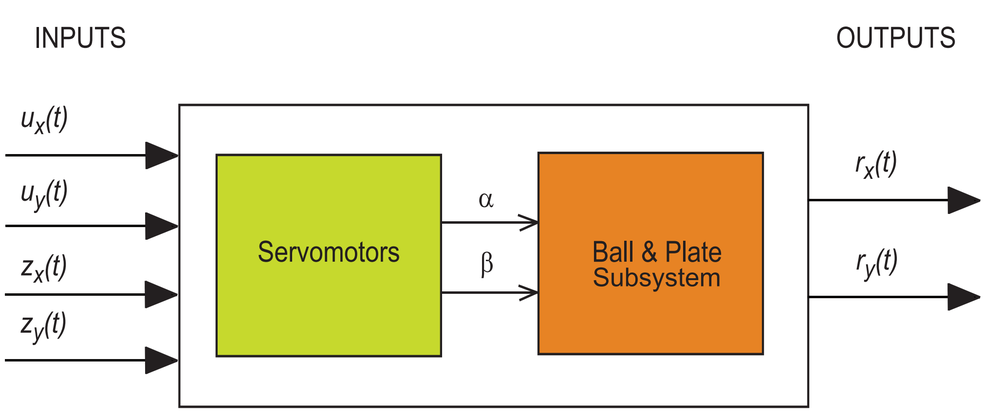


Fig. 1 System Ball & Plate - inputs/otputs

$u_x(t)$, $u_y(t)$ - voltages of servomotors for axis x and y - control inputs
$z_x(t)$, $z_y(t)$ - external forces for axis x and y - disturbance variables
α, β - angles of plate's leaning for axis x and y
$r_x(t)$, $r_y(t)$ - actual positions of the ball for axis x and y - controlled variables

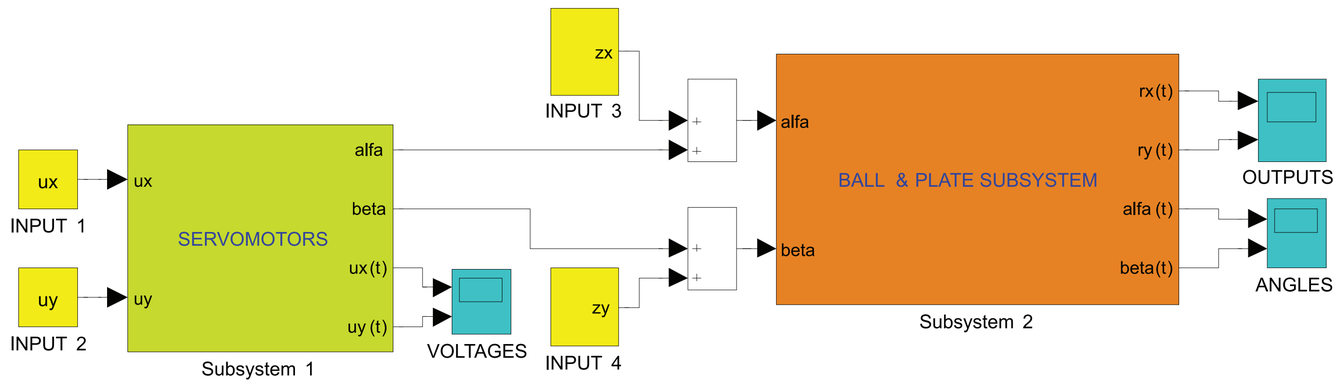


Fig. 2 Scheme of non-linear model of dynamical system Ball & Plate

Inputs parameters:

$u_x(t) = 1\text{V}$
$u_y(t) = -0{,}2\text{V}$
$z_x(t) = z_y(t) = 0$
$r_x(0) = r_y(0) = 0$

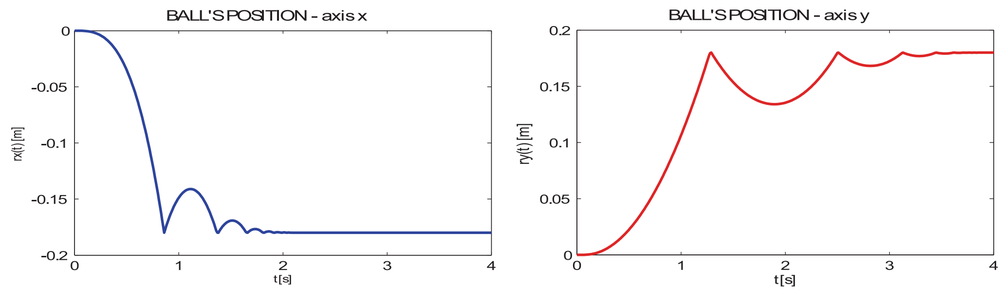
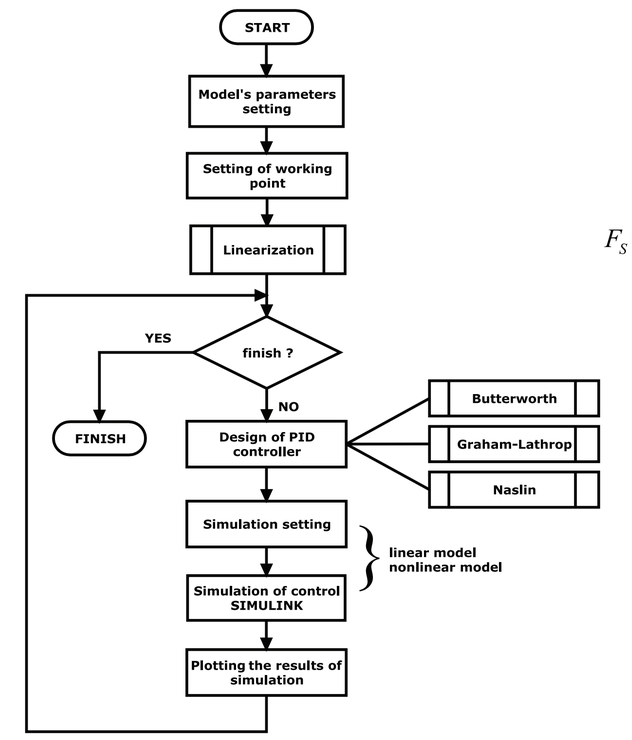


Fig. 3 Time responses of ball's position

Control algorithms



$$F_S(s) = \frac{4{,}803}{s^2(0.1878s + 1)}$$

Tab. 1 Parameters of PID controller

Method of synthesis	*Parameters of PID controller*					
	P	***I***	***D***	K_p	T_i	T_d
Naslin (δ_{max} = 3%)	0,56	0,28	0,51	0,56	1,99	0,91
Graham-Lathrop	1,73	1,64	0,86	1,73	1,06	0,5
Butterworth	0,87	0,69	0,56	0,87	1,27	0,64

Inputs parameters:

$r_x(0) = -0{,}18\text{m}$ $r_y(0) = -0{,}18\text{m}$

$\alpha(0) = \alpha_{max} = 1$ MU $\beta(0) = \beta_{max} = 1$ MU

$z_x(t) = z_y(t) = 0$

reference trajectory = star

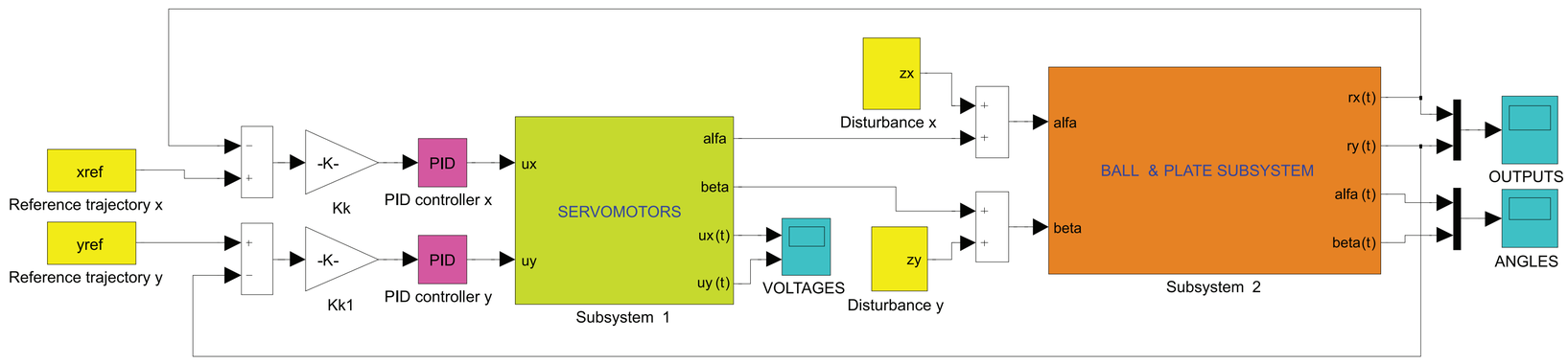


Fig. 4 Algorithm for analysis of dynamics during control process

Fig. 5 Control close loop scheme of the system Ball & Plate in Simulink

Verification of control algorithms

simulating, PD controller, T_{VZ} = 0,01s ←

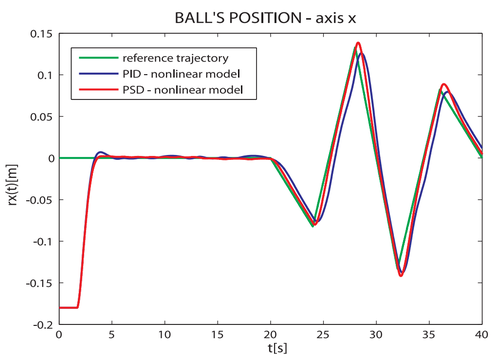


Fig. 6 Ball's position on the plate in the direction of axis x

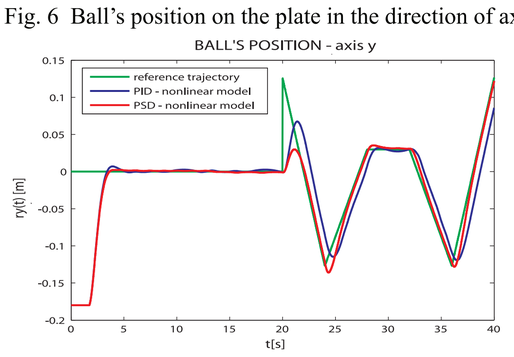


Fig. 7 Ball's position on the plate in the direction of axis y

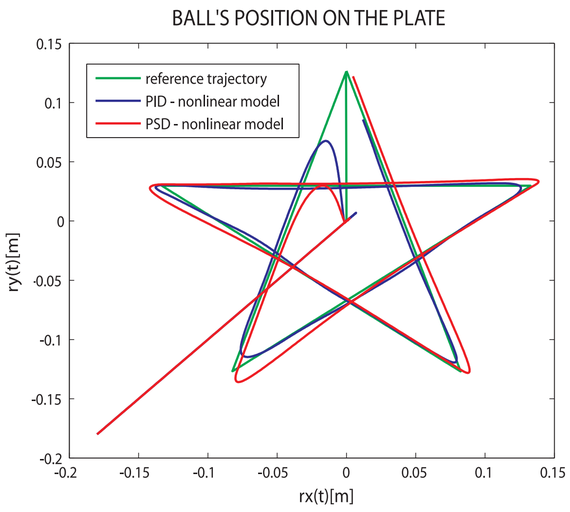


Fig. 8 Position of the ball on the plate

→ real, PSD controller, T_{VZ} = 0,15s

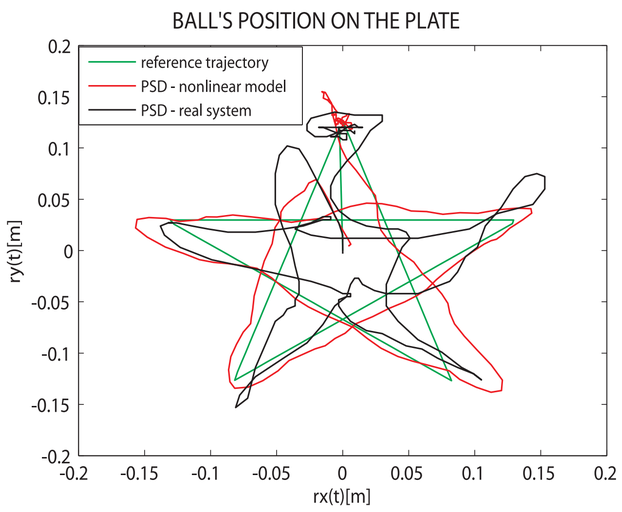


Fig. 11 Position of the ball on the plate

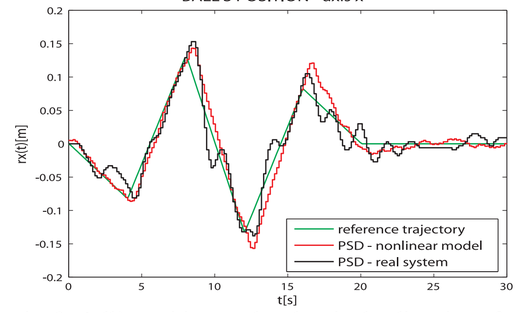


Fig. 9 Ball's position on the plate in the direction of axis x

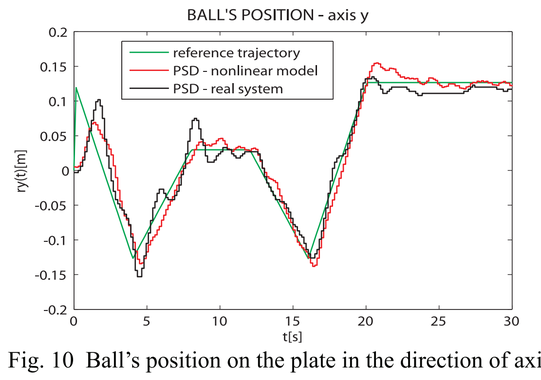


Fig. 10 Ball's position on the plate in the direction of axis y

http://matlab.fei.tuke.sk/ss/aplikacie.aspx

This research has been supported by the Scientific Grant Agency of Slovak Republic under project Vega No. 1/0617/08 *Multiagent Network Control Systems with Automatic Reconfiguration.*