

# Adaptive CPG-based Gait Planning with Learning-based Torque Estimation and Control for Exoskeletons

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The initial state values, threshold and extreme values, and the CPG parameters in Eqs. (2), (4) and (5) for the hip ( $H$ ) and knee ( $K$ ) joints in the corresponding paper are provided in Table I.

Initial state values	$\omega(0) = 1.57 \text{ rad/s}$ , $\rho(0) = 1$ , $\xi_H(0) = 10.13 \text{ deg}$ , $\xi_K(0) = 23.44 \text{ deg}$ , $\phi_{H/K_{Right}}(0) = 2 \text{ rad}$ , $\phi_{H/K_{Left}}(0) = 2 + \pi \text{ rad}$ ,
Parameters and gains	$\gamma_\omega = 22$ , $\Omega = 0.94$ , $\psi_H = 0.141$ , $\psi_K = 0.141$ , $\gamma_\rho = 22$ , $A_{\rho_H} = 1$ , $A_{\rho_K} = 1$ , $\lambda_H = 0.056$ , $\lambda_K = 0.056$ , $k_\rho = 1.6$ , $\gamma_\xi = 22$ , $A_{\xi_H} = 10.13$ , $A_{\xi_K} = 23.44$ , $\beta_H = 2$ , $\beta_K = 2$ , $k_{\xi_1} = 5$ , $k_{\xi_2} = 5$
Threshold and extreme values	$\rho_{H_{th}} = 1.1$ , $\rho_{K_{th}} = 1.15$ , $\rho_{H_{max}} = 1.2$ , $\rho_{K_{max}} = 1.2$ , $\xi_{H_{th+/-}} = 10.13 \pm 5 \text{ deg}$ , $\xi_{K_{th+/-}} = 10.13 \pm 6 \text{ deg}$ , $\xi_{H_{max/min}} = 10.13 \pm 8 \text{ deg}$ , $\xi_{K_{max/min}} = 23.44 \pm 9 \text{ deg}$
Fourier coefficients of hip	$a_0 = 10.13$ , $a_1 = 21.80$ , $a_2 = -5.07$ , $a_3 = -0.49$ , $a_4 = -0.52$ , $a_5 = 0.20$ , $a_6 = -0.07$ , $a_7 = -0.09$ , $a_8 = -0.09$ , $b_1 = -10.77$ , $b_2 = -2.21$ , $b_3 = 1.86$ , $b_4 = 0.41$ , $b_5 = 0.20$ , $b_6 = -0.06$ , $b_7 = -0.05$ , $b_8 = -0.05$
Fourier coefficients of knee	$a_0 = 22.44$ , $a_1 = -2.93$ , $a_2 = -14.32$ , $a_3 = 0.05$ , $a_4 = -0.38$ , $a_5 = 0.36$ , $a_6 = 0.20$ , $a_7 = -0.01$ , $a_8 = 0.03$ , $b_1 = -26.48$ , $b_2 = 9.81$ , $b_3 = 4.44$ , $b_4 = 1.87$ , $b_5 = 0.59$ , $b_6 = -0.15$ , $b_7 = -0.08$ , $b_8 = -0.07$

TABLE I

INITIAL STATE VALUES, THRESHOLD AND EXTREME VALUES, AND PARAMETERS OF THE PROPOSED CPG DYNAMICS (2), (4) AND (5) FOR THE HIP ( $H$ ) AND KNEE ( $K$ ) JOINTS