



Self-Balancing Robot

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GOOGOL TECHNOLOGY

An inverted pendulum system is a highly coupled multivariable, nonlinear and unstable system. It is the perfect experimental device to examine various control theories. Controllability, stability, robustness and some other key performance in control will be examined in the process of controlling such system.

The self-balancing robot is in fact a movable 3 DOF inverted pendulum system. The system, taking the gyro as feedback, is balanced by outputting different torque in two wheels.

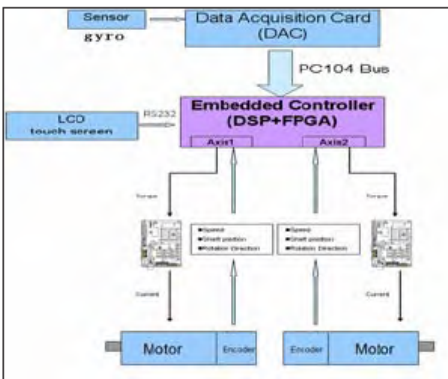
System Model

$$\begin{bmatrix} \dot{x}_p \\ \dot{x}_r \\ \dot{\theta}_p \\ \dot{\theta}_r \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & A_{23} & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & A_{43} & 0 \end{bmatrix} \begin{bmatrix} x_p \\ x_r \\ \theta_p \\ \theta_r \end{bmatrix} + \begin{bmatrix} 0 \\ B_2 \\ 0 \\ B_4 \end{bmatrix} [C_d]$$

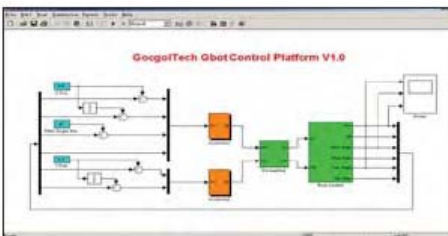
$$\begin{bmatrix} \dot{\delta} \\ \ddot{\delta} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \delta \\ \dot{\delta} \end{bmatrix} + \begin{bmatrix} 0 \\ B_6 \end{bmatrix} [C_\delta]$$

x_p : Robot Position, θ_p : Robot Tilt angle, δ : Robot Yaw angle, C_d : Torque of motor

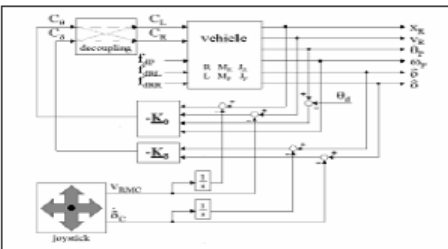
System Diagram



MATLAB Interface



Plant Diagram



System Characteristics:

1. More degree of freedom compare to linear and planar inverted pendulum
2. Using real-time workspace in MATLAB
3. Embedded PC104 system with windows operating system
4. Online editing and modifying the control algorithm
5. Various extension interface for add-on sensors, e.g. vision
6. Providing MATLAB functions



Specifications	
L x W x H	260mm x 450mm x 730mm
DC Servo Power	85W
Gear Ratio	8:1
Motion Controller	<ul style="list-style-type: none"> • DSP and FPGA based embedded Controller • PC104 bus • 3 Axes Motion Controller
Software Environment	WIN 98/ MATLAB 6.5
Maximum Speed	1.6m/s
Power	NiMH Battery 8.5Ah (24V)
Duration	>1.5H
Maximum Loading	3 Kg
Maximum Ramp Angle	20 Degree
Gyro	<ul style="list-style-type: none"> • Power 9~12V • AD/DA resolution 12 bits • Current 30mA • Maximum angular velocity ±300 deg/sec (25°C) • Range 360° (25°C) • Sampling Frequency 150HZ • Temperature Bias ± 0.025%/°C • Operating Temperature -40~50°C • Analog Output (0~4.096V) • Repeatability 0.10° • Weigh 20g

Ordering Guide

Model Number	Product Name	Product Configuration
GBOT-1001	Self-Balancing Robot	<ul style="list-style-type: none"> • Self-Balancing Robot Main Body • Self-Balancing Robot Software • GogolTech's Simulink Toolbox

Reference Experiments

- Gyro application and experiments
- System Modeling
- Open Loop System Analysis
- PID Controller Design
- Pole Placement Controller Design
- LQR Controller Design
- User Defined Controller Design

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