Sudan University of Science and Technology

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Study of Self-tuning Adaptive Proportional -Integral -Derivative controller

دراسة حاكمة الضبطـالذاتي التكيفى النسبيةـالتكامليةـالتفاضلية

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ABSTRACT

This thesis describes a procedure for tuning PID controller .The key idea is to used a method base on self-tuning adaptive system to estimate PID parameters.

The Ziegler-Nichols based self-tuning method design, the recursive Least-squares (RLS) method, and the projection algorithm for plant estimation are studied in this work. Simulation studies for the estimation and controller algorithm are mainly undertaken a after use MATLAB self-tuning controller Simulink library (STCSL).

Simulations results show that adaptive controller has a better performance compared with classic feed back controller especial in appear of noise and set point changing.

Since PID controllers are largely used in the industries, the method testing in this work can be used in similar problems process control, robotic, among another industrial application.

تجريد

هذا البحث يصف طريقة لضبط حاكمة PID .الفكرة ألأساسية استعمال طريقة تعتمد علي نظام الضبط–الذاتي التكيفى لتقدير عناصر PID.

طريقة زيقلر–نايكلوس المعتمدة علي الضبط–الذاتي وصفت ، وصيغة المربعات–الصغرى التكرارية ، وفكرة خوارزمية النظام قد درست .دراسات المحاكة لخوارزمية الحاكمة قد أخذت بعد استخدام مكتبة محاكاة حاكمة الضبط–الذاتي عن طريق برنامج MATLAB.

نتائج المحاكاة تبين أن حاكمة نظام التحكيم التكيفى لها أداء أفضل من الحاكمة التقليدي ة ذات الحلقة المغلقة ،خاصة عند تعرض النظام للتشويش والتغيير في نقطة النظام المرجعية.

وبما أن حواكم PID تستعمل بكثرة في الصناعة ،فأن هذه الطريقة التي اختبرت في هذا البحث يمكن أن تستخدم لحل مشاكل مشابه في مجال التحكم العملياتي ،الإنسان الآلي، وتطبيقات صناعية أخري.

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LIST OF SYMBOLS

- e, E: Scalar error signal and a k×m matrix containing error signal values
- f(·): Arbitrary function
- F: Linear mapping matrix of dimension n×m
- G,g: Transfer function (for a process, closed loop system etc.),Scalarfunction
- i,j: Indices for vector and matrix elements
- J(·): Cost function
- k: Number of data samples, i.e., local iteration steps
- K: Number of global iteration steps
- Kc: Critical gain of the controller
- Ku :Control gain at the stability limit
- Kp: Proportional gain of the PID controller
- L: Time lag, delay
- L(·): Filter transfer function
- m: Number of quality measures; dimension of output space
- M: Number of latent basis vectors in output oriented subspace
- n: Number of the parameters; dimension of input space
- N: Number of latent basis vectors in input oriented subspace
- P_u : Period of oscillation at the stability limit
- q, Q: Quality measure vector and matrix, dimensions m×1 and k×m, respectively;shift operator
- r: Reference signal; setpoint
- Rn: n-dimensional linear space
- s: Lap lace variable
- t: Continuous or discrete time index
- T_I : Integration time
- T_D : Derivation time

- T_R: Rise time
- T_S : Settling time
- X: Random variable
- u: Input signal, control signal
- v: Disturbance signal
- w: Weight vector of compatible size
- y: Output signal
- y_m : Model output
- z, Z: Latent variable vector and matrix, dimensions N×1 and k×N, respectively
- γ: Scalar step size
- κ: Data sample index 2
- λ: Eigen value; Lagrange multiplier
- θ, Θ: Parameter vector and matrix, dimensions n×1 and k×n, respectively
- τ: Time constant of a process
- ζ : Damping factor

NOTATIONS

- M*: Optimal or objective value of M
- M : Nominal (prevailing) value of M
- $\hat{M}$: Estimate of M
- M^T : Transpose of M
- M°: Unit vector parallel to vector M
- Mi: The ith column of the matrix M or ith element of vector M
- Mij: The element on the ith row and jth column of matrix M

ABBREVIATIONS

- BRM : Back rectangular method
- Eg: Equation
- FRM: forward rectangular method
- LS: Least Squares (method)
- MIMO: Multiple inputs, multiple outputs (model, system)
- MRAC: Model-Reference Adaptive Control

- LMS: Least-square method
- PID : Proportional &Integral &Derivative controller
- RLS : Recursive least-square
- SOC: Self organizing control
- SISO: Single input, single output (model, system)
- SPM: Statistical Process Monitoring
- STR: Self-tuning Regulator
- TRM : Trapezoidal method
- Z-N : Ziegler and Nichols