بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

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التوثيق الالكتروني والميكروفيلم

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأفلام قد اعدت دون آية تغيرات

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To be kept away from dust in dry cool place of 15 – 25c and relative humidity 20-40 %

بالرسالة صفحات

لم ترد بالأصل

MENOUFIA UNIVERSITY
FACULTY OF ELECTRONIC ENGINEERING
MENOUF

OPERATION OF INDUSTERIAL ROBOT USING FUZZY LOGIC

A THESIS
Submitted for M. Sc. Degree
in
Automatic Control System

By

MAGDY GAMAL MOHAMMED EL-GHATWARY

B. Sc. AUTOMATIC CONTROL AND MEASUREMENTS
MENOUFIA UNIVERSITY, 1993.

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ABSTRACT

In Recent years, fuzzy control has grown in popularity, its use has been proposed in applications that extend beyond those which it is sought to replace human operators. Fuzzy control is now often considered for applications in which human operators have never been used, e.g. servomechanism. In such applications, it is the facility of fuzzy systems to act as function approximates. However, the issue arises of how to design nonlinear fuzzy control laws. Many fuzzy controllers have been constructed, instead of systematically designed, case by case using the trial-and-error method guided by designers experience on fuzzy control. This approach may be adequate for simple problems. However, for more complex systems such as industrial robot there is an urgent need for formal design methods of fuzzy controllers. Fuzzy model reference adaptive control and other adaptive fuzzy control approaches seek to address this issue . The main advantage of the FMRAC is that it implements an adjustable nonlinear mapping between inputs and outputs. Despite the many advantages of the fuzzy model reference adaptive control (FMRAC) algorithm, several drawbacks do exist : The FMRAC design procedure tends to be very
ad hoc, and the development of linguistically expressed fuzzy inverse model is difficult for complex physical systems. In this thesis basic ideas from fuzzy logic and conventional control theory are employed to systematically design a FMRAC for industrial robot. A fuzzy inverse model is designed using numerical input-output data of the process. An adaptive control algorithm is used in setting up the scaling factors of primary fuzzy controller.

The adaptation mechanism performs the function of modifying the centers of consequent membership functions of primary fuzzy controller so that the closed-loop system behaves like the reference model. The proposed procedure eliminates the tedious and time consuming trial-and-error efforts required presently in constructing model reference fuzzy controllers.

ABBREVIATIONS

MRAC	Model Reference Adaptive Control
FLC	Fuzzy Logic Controller
FMRAC	Fuzzy Model Reference Adaptive Control
FIM	Fuzzy Inverse Model
DFC	Direct Fuzzy Controller
SOC	Self-Organized Controller
SISO	Single Input Single Output
MISO	Multi Input Single Output
PI	Proportional integral controller
PD	Proportional derivative controller
PID	Proportional integral derivative controller

List of symbols

^{A}P Position vector defined along the coordinate system {A} P(t)

Position vector defined along cartesian coordinate system

$^{A}R_{B}$	Rotation matrix representing the orientation of the body in coordinate system{B} relative to coordinate system {A}
X_1	Vector representing the end-effector position and orientation in cartesian Coordinates
$\theta(t)$	Position of end-effector in Cartesian coordinate
τ_g	Gravitation torque
n	Number of robot joints
noi	Measurement noise
$F_2(t)$	Force generated due to auxiliary signal
$F_3(t)$	Force due to payload acceleration
s	Complex frequency
Lo	Load disturbance

e (kT)	Error between the actual and desired displacement
$\Theta(t)$	Deviation of joint angles from their nominal values at the P_1
T(t)	Deviation of joint torques from their nominal values at the P_1
Θr	Desired incremental angle vector
θ_r	Desired joint angle vector
$\dot{\theta}_r$	Desired velocity
$\ddot{\theta}_r$	Desired acceleration
$\dot{\theta}$	Velocity of the end-effector
$\wedge(\theta)$	Vector representing the forward kinematics
$J(\theta)$	Jacobean matrix of the manipulator
$M(\theta)$	Symmetric positive definite inertia matrix
$N(\theta, \dot{\theta})$	Coriolis and centrifugal torque
$G(\theta)$	Gravitational load vector
$H(\dot{\theta})$	Friction torque vector
g	Gravitational acceleration vector
$J'(\theta)$	Transpose of the Jacobean matrix
X	Universe of discourse of variable x
Y	Universe of discourse of variable y
x	Element of X
F, A_i, B_i, C_i,	Fuzzy sets for i. = 1,2,….,n
D_i, G_i	Fuzzy sets for i. = 1,2,…,n
μ	Membership degree
y_r	Desired process output
y	Actual process output
ce (kT)	Change of error
u	Control signal
Δu	Change of control signal
K_P	Proportional gain coefficient

K_d	Differential gain coefficient
k_i	Integral gain coefficient
W(s)	Transfer function of plant
Q(s)	Inverse model of the plant
p_1	Operating point
U_{fb}	Feed back control signal
U_{ff}	Feed-forward control signal
U_{ax}	Auxiliary control signal
U	Control signal
m	Mass of payload
A, B, C	nxn matrices
A*, B*, C*	nxn matrices whose elements are highly complex non linear functions of θ, $\dot{\theta}$ and m
ζ	Damping ratio
ω_n	Natural frequency
Q_1	Symmetric positive definite constant matrix
w_p, w_v	Weighting matrices
x_1, x_2	Inputs of the controller
K_V	Velocity gain constant
k_{pro}	Process gain
R(t)	Weighted error vector
Z(t)	Error states of the Robot
$Z_m(t)$	Error states of the reference model
C^j_v	Center of the j th membership function of the variable v.
r_v	Range of variable v
T	Sampling period
$y_e(kT)$	Error between model reference output and plant output
$y_{ce}(kT)$	Deviation of $y_e(kT)$

D_{ie}	Membership function of error for DFC
D_{ice}	Membership function for change of error for DFC
D_{iu}	Membership function for control signal for DFC
$\chi_i(kT)$	Strength of firing of the rule i. for DFC
C_{in}	Centroid of the consequent fuzzy set D_{iu} for DFC
$y_m(kt)$	Reference model output
g_e	Scaling factor for error in DFC
g_{ce}	Scaling factor for change of error in DFC
g_u	Scaling factor for control signal in DFC
g_{ye}	Scaling factor for error in FIM of the plant
g_{yce}	Scaling factor for change of error in FIM of the plant
$g_{\Delta u}$	Scaling factor for deviation in control signal(output of FIM)
Δu^*	centroid of consequent fuzzy set C_{iu} for FIM
σ	Positive constant in the range $0.1< \sigma<1$
G_{ie}	Membership function of error in FIM
G_{ice}	Membership function for change of error in FIM
G_{iu}	Membership function for control signal in FIM
d	Distance between the membership functions
Ψ	Parameter that quantifies the speed of iteration
T_i	Integral time
T_d	Derivative time
$\tau_T(t)$	Total torque due to payload
τ	Time duration

CONTENTS

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CHAPTER 2

CHAPTER 3

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CHAPTER 5

FUZZY RULE BASE GENERATION AND FUZZY MODEL REFERENCE ADAPTIVE CONTROL

CHAPTER 6

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