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Thereference model adaptive control is based on Job van Amerongen's equation

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ABSTRACT: This paper introduces the formula given by Professor Job van Amerongen for the problem of designing adaptive controller according to the model reference. We have introduced two design alternatives: using direct adaptive controller and indirect adaptive controller. The simulation results show that: the indirect adaptive controller applying the Job van Amerongen formula gives really good quality. The analysis and design steps are simulated under the support of 20-SIM software..

KEYWORDS: The model reference, The PID controller, Adaptive control according to the model reference.

I. INTRODUCTION

The PID controller is an effective solution for most industrial control applications. The PID controller combined with the basic feedback loop is used to change the control signal to affect the object. However, this controller has two problems: the controller is very sensitive to measurement noise and the setting of fixed PID coefficients is only responsive to a system with little parameter changes. Therefore, with high quality requirements, this controller in general has not been met.

In practice, the designer wishes to design a controller that is less sensitive to measurement noise and object parameter changes. The disadvantage of traditional PID controller can be solved by applying adaptive controller.

There are two types of adaptive control system: The model reference adaptive controller (MRAC) and The self-tuning controller (STR).

There have been many research topics on adaptive control according to the model model, but most of the previous studies have only provided methods for designing control structures without giving a specific formula or the introduction of models. It is also very complicated, very difficult to implement in practice. Therefore, finding an accurate, easy-to-understand, and easy-to-implement formula in practice is a research problem that is attracting many people's attention.

II. THE STEPS DESIGN THE ADAPTIVE CONTROLLER WITH THE LIAPUNOV METHOD.

Step 1: Determine the differential equation for e
Step 2: Select a liapunov V function
Step 3: Determine the below condition for dV/dt to be negative.
Step 4: P finded from the 2.1 equation

$$A_m^T P + PA_m = -Q \quad (2.1)$$

III. THE DESIGN MRAC CONTROLLER IS BASED ON LIAPUNOV THEORY OF STABILITY –INTRODUCION THE JOB VAN'S EQUATION

From the design steps of the adaptive controller with liapunov method, Job van Amerongen gave the following regulation law:

$$K_{a_{ni}} = -\frac{1}{\alpha_{ni}}\int_0^t \left(\sum_{k=1}^{n} p_{nk}e_k\right)x_i dt + K_{a_{ni}}(0) \quad (3.1)$$

$$K_{b_{ni}} = \frac{1}{\beta_{ni}}\int_0^t \left(\sum_{k=1}^{n} p_{nk}e_k\right)u_i dt + K_{b_{ni}}(0) \quad (3.2)$$

With:
n is the order of the system.
p_{nk} are the elements in the n^{th} row and k^{th} column of the matrix P.
Q is a positive definite matrix selected before.
α, β is a positive definite diagonal matrix, determining the rate of adaptation

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IV. APPLICATION OF THE JOB VAN AMERONGEN'S EQUATION DESIGN A DIRECT MRAC CONTROLLER

Consider this example:

The transfer function of object: $\frac{b_p}{s^2 + a_p s + 1}$ (the a_p, b_p parameters of the object are changed)

The reference model with transfer function: $\frac{b_m}{s^2 + a_m s + 1}$ or $\frac{K\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$

The object model and the reference model are described as the state space:

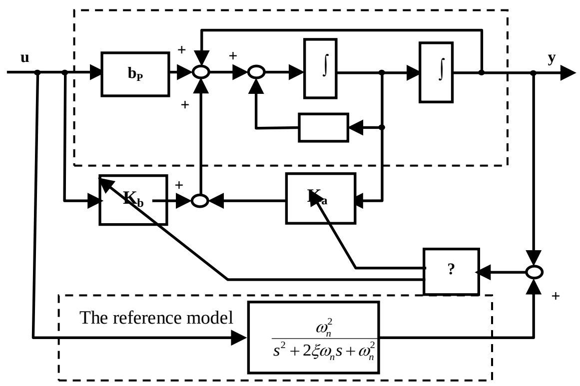

Figure3.1: The Object model and reference model

Applying the Job van Amerongen's equation, we have the following adaptive control law:

$$K_a = -\frac{1}{\alpha_{22}}\int_0^t (p_{21}e_1 + p_{22}e_2)x_2 dt + K_a(0) \quad (3.1)$$

$$K_b = \frac{1}{\beta_2}\int_0^t (p_{21}e_1 + p_{22}e_2)u dt + K_b(0) \quad (3.2)$$

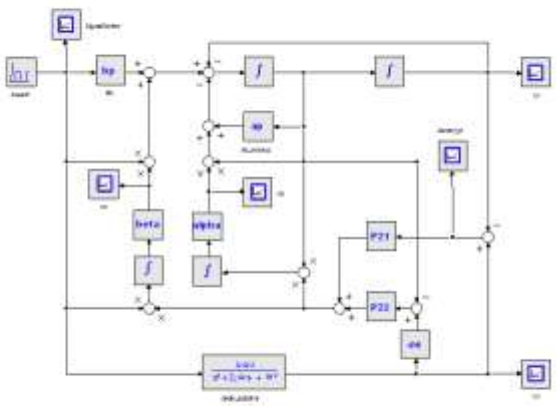

Figure3.2: The adaptive system is designed according to the Liapunov stabilization method.

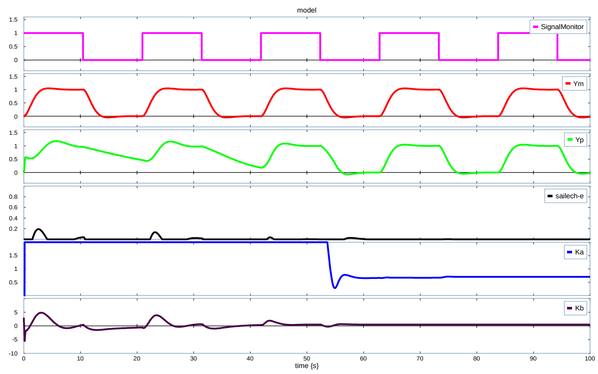

Figure3.3: Output response of sample model (Y_m), object model (Y_p), error (e), and tuning parameters (K_a, K_b).

V. APPLICATION OF THE JOB VAN AMERONGEN'S EQUATIONDESIGN A DIRECT MRAC CONTROLLER

Although the direct MRAC controller is suitable for objects with variable parameters and control signals act quickly. But it only works when the object parameter is known. When the parameter of the object is unknown, the direct MRAC controller set has not yet responded.

When the object is affected by noise, this noise will be injected into the control signal, the error signal will carry this noise to affect the MRAC controller directly, the received response will be inaccurate.

The requirement is to design a controller that can respond when the object parameters are unknown and change during the working process. At the same time when the object is affected by noise, the control signal must be clean noise and exacting.

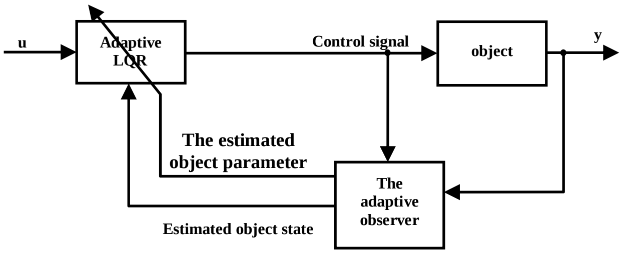

Figure4.1: MRAS applies to identification

When the object and the reference model are interchanged, the reference model is considered as a adjustmentable model.It will follow to the response of the object. This is done by adjusting the parameters of the adjustment model.

The Job van Amerongen 's equation is used to identify object parameters.

The results of the identification can be used to adjust the control parameters. For example, the minimization – with the help of the Ricatti equation – by the standard is:

$$J = \int (\varepsilon^2 + \lambda \delta^2) dt \qquad (4.1)$$

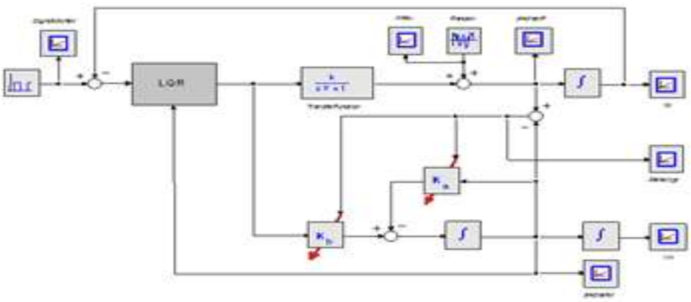

Figure4.2: Identification results for controller calculation - optimal K_p ,K_d according to the Ricatti equation

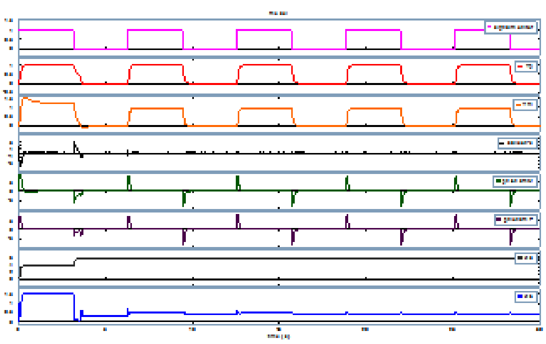

Figure4.3: Output response when the measurement noise is impacted into the object

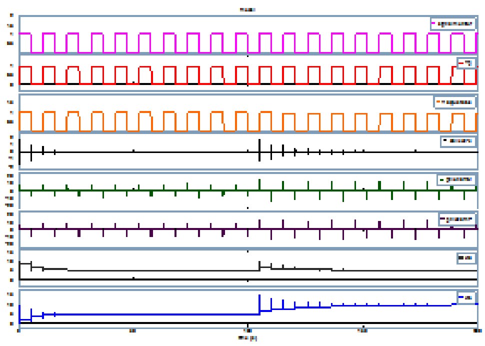

Figure4.4: Simulation results, optimization results of online controller parameters based on Ricatti equation (the system is affected by system noise at t=100s).

VI. CONCLUSION

Apply the equation given by Job van Amerongen to build a control mechanism for the direct MRAC controller (when the object's parameters are known and change), or the indirect MRAC controller (when the object's parameters are unknown and change). The advantage of the direct MRAC controller is that the control signal is fast, but these signals also carry noise.

A special feature when applying the equation of Job van Amerongen to build an adaptive structure for the indirect MRAC controller is that the state and identification parameters of the object are completely free of noise. Therefore, the state and parameters are recognized when put into the controller, which will give a good control signal. The output signal of the object accurately tracks the input signal, the control error is very small and approaches zero in a very short time. The controller parameters are designed to approach stable steady-state values..

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