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Comparison between model reference discrete time indirect and direct adaptive controls

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Abstract

The discrete time Model Reference Adaptive Control (MRAC) techniques have some important properties. They can be used successfully to the control of different type of Single Input and Single Output (SISO) systems: Linear Time Invariant (LTI) systems with unknown parameters and Linear Parameter Varying (LPV) systems. This method can be considered also as a nonlinear control design, where the system parameters will be updated in each iteration.

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Keywords: model reference adaptive control; direct and indirect control; discrete time control; system identification; forgetting factor; covariance.

1. Introduction

In general case the aim of the control system is too keep the output signals of a given plant within prescribed limits. The adaptive control refers to the control of partially known systems. While we have to control a real process, very rarely know the parameters accurately. The parameters or characteristics of the process can change with time (unforeseen change of the external input signals or disturbances). The adaptive control is represent a special control system what is capable to monitories his own performance. If this value of the performance is suffer some deterioration, than it is capable to adjust their control parameters in the direction of the better performance.

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Therefore in general case, the adaptive control systems have two feedbacks. One of these is representing the classical control feedback, and the other is representing the parameter adjustment feedback.

The Model Reference Adaptive Control (MRAC) and the Self Tuning Regulators are two classes of the adaptive control systems, which achieve this objective. The principal approach of the Self Tuning Regulators is the indirect control, where the parameters of the controlled process are estimated on-line prior to determining the control parameters. The objective of the MRAC is to create a closed loop control systems, where the controller parameters can be modified to change the output signal of the controlled process. This output signal is compared to a desired response of the reference model [1, 2].

In this paper, we study only the discrete time adaptive control approach. The discrete time MRAC algorithms can be implemented with different parameter identification methods or algorithms, in both cases: direct and indirect adaptive control. In this paper we discuss some theoretical aspects concerning the indirect and direct discrete time model reference adaptive controls and some important aspects about their implementation. The parameters identification method will be the recursive least square algorithm. First we study the non-adaptive version of the pole placement control design with model reference approach, and we compare the results of direct and indirect adaptive control methods.

The organization of the paper is as follows. In section 2 we present some theoretical aspects about adaptive control approaches. In section 3 we make a brief presentation about model reference control with pole placement design for the known process. After that in section 4 we present the adaptive version of this control, when the process has some unknown parameters. This problem can be resolved in two ways indirect method and direct method. In section 5 we present one example, where we simulate the presented control methods for one theoretical LTI system and we make one comparison between indirect and direct adaptive control methods.

2. Model reference adaptive control, indirect and direct control approaches

The model reference adaptive control (MRAC) is an important class of the adaptive control systems. The objective of this control system can be formulated as follows. The outputs of the controlled process (yp(t)) have to follow the outputs signal of the priory selected reference model (ym(t)). The general structure of the MRAC is shown in Fig. 1, where yref(t) is the reference signal, u(t) is the control signal and θ(t) is the parameter vector of the controller.

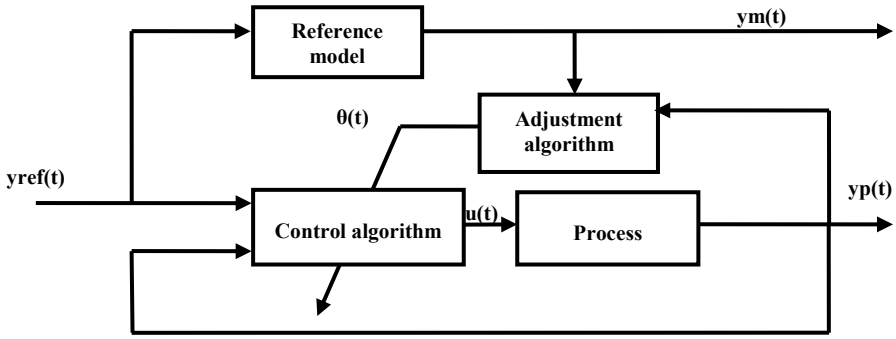

Fig. 1. General structure of the MRAC.

In MRAC design the primary problem is to choose the reference model and select one suitable control algorithm. To choose one adequate reference model we have to give some prior information concerning the controlled plant. For the control algorithms we can choose one model based controlling algorithms, for example Linear Quadratic Regulator (LQR), Model Predictive Control (MPC), Minimum Variance Control (MVC) or one pole placement control algorithm [7, 8, 10].

The control problem can be attempted using either an indirect and direct control approach. In the case of indirect adaptive systems, the adjustment of the control system is based on recursive identification of the process, while in the case of direct adaptive system this is based on recursive identification of the controller parameters.