Predictive Control for Mechatronic Laboratory Models

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Abstract: With steady growth of production, there is a necessity to develop different ways of the control of individual components included in the production process. The components usually combine some mechanical elements (mechanisms) and elements, mostly electrical, which power (actuators – drive units), monitor (sensors) or control (control units) the component state itself; i.e. altogether, it represents combination of mechanics and electronics, in single word – mechatronics.

The main purpose of the control often consists in fulfillment of some predetermined motion or in stabilization. The question is: 'How to achieve such purpose?'. One of the possibilities, being at the beginning of industrial application, is approach based on model-based control strategies. They offer complex solution on global level of whole controlled system and not only of its individual elements. In this contribution, as a powerful way, the predictive control is presented [1], [4]. The main stress is laid on obtaining of suitable model and its on-line use (adaptation) within control design.

The explanation is intended for simple mechatronic systems, which are considered as Single-Input/Single-Output type or possibly the systems with low number of inputs and outputs. However, the methods of adaptation and model-based control are not generally limited to this condition. The model, describing the relations among inputs and outputs, i.e. dynamics of controlled system, represents very important part, which includes specifically processed information for design of control actions.

The best results of control process are achieved, when the model is obtained on the basis of thoroughgoing mathematical and physical analysis. It is often difficult. Therefore, different ways, how to obtain the model of the controlled system, are investigated.

Selection of model form is determined by used model-based control, in which the model is involved. Due to digital character of automating devices, the discrete control techniques are preferred. Therefore, the resultant models for control design are also discrete in spite of the facts that controlled system may be continuous. Discrete realization is advantageous, because naturally respects finite and predefined time for computation of control actions.

The combination of on-line identification and generalized predictive control will be introduced here. The identification is based on least squares [3], which identifies the parameters of autoregressive model with external input (ARX model) describing real controlled mechatronic system [2].

The predictive control is a multi-step approach, combining feedforward and feedback control design [1]. Feedforward is represented by predictions based on mathematical model. This part is dominant component of control actions. Feedback from measured outputs serves for compensation of some bounded model inaccuracies and low external disturbances.

The design consists in local minimization of quadratic criterion, in which the predictions of future outputs are involved. The predictions are determined from specific equations of predictions. The minimization is repeated in each time step.

The predictive control arises from state-space formulation [1], of which idea is applied to ARX models representing Input/Output formulation. The equations of predictions, forming the main part of predictive design, are specifically composed in pseudo-state form from identified parameters of ARX model. This form requires only values of inputs and outputs. Their number corresponds to the order of controlled system.

To compose equations of predictions from available ARX model, there are several possibilities how to do it. One of the possibilities is to express the equations directly from ARX model. It is possible according to [4]. However, such way requires solution of Diofantic equation and storing previous values of inputs and outputs as in further 'pseudo state-space' possibilities. These 'pseudo state-space' possibilities are generally called as state-space forms with non-minimal state. They will be helpful for the use of idea of state-space formulation in predictive control, in which forming needed equations of predictions consists in repetitive insertion of state-space model. One new suitable state-space non-minimal form will be presented. Its advantage is that keeps the dimensions of elements in the equations.

The presented algorithms are derived in computationally suitable square-root form [5], [6] and will be demonstrated by several real laboratory tests.

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