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ADAPTIVE LQ CONTROL WITH PRE-IDENTIFICATION OF TWO TANKS LABORATORY MODEL

PERUTKA, K[arel]

Abstract: *The paper deals with the control of laboratory model using the pre-identification procedure. The laboratory apparatus consists of two interconnected tanks. The main task of the control was to control the given water level in both tanks. The given continuous-time TITO (two input two output) model of the controlled system was firstly divided to the regions according to the change of at least one of the set-points and pre-identified using recursive instrumental variable method. The results of identification was verified with the measured response and stored. After that, the self-tuning control using suboptimal LQ (linear quadratic) control was realized. For that purpose, MATLAB software together with the Real-time toolbox and Humusoft technological card was used.*
Key words: *LQ control, MatLab, real-time, self-tuning, TITO systems*

1. INTRODUCTION

During last years, it was proven the globalization has to be taken into account also in the area of control theory and practice. Nice paper about new possibilities and risk factors of globalization and technology was presented by Katalinic (Katalinic, 2003).

Many processes can be described by multivariable systems. In this case, the centralized controllers are commonly used because they provide the best closed loop performance. However, the centralized controller is less fault tolerant than the decentralized controller. This is why the decentralized control strategy is often preferred. The plant decomposition is crucial for decentralized controller design and it is not always possible to obtain satisfactory decentralized control systems using a simple physical decomposition (Li et al., 2000). However, the decentralized approach has one big disadvantage due to the decomposition, the reduction of control performance due to the restricted controller structure (Cui & Jacobsen, 2002).

It is commonly known that the water level in the tank is sensitive on the changes of the flow therefore better fault tolerant controller is requested. It is the decentralized controller. For instance, the decentralized approach in motion control and in Air Traffic Management has a lot of applications, see (Dimarogonas & Kyriakopoulos, 2005).

The sensitivity to the changes of the flow can be decreased for instance by the usage of adaptive control combined with the decentralized control. There are many papers dealing with the decentralized adaptive control (Wen & Soh, 1997). They prove the usefulness of this approach for several years. Effective method of adaptive control can be successfully used at the system with the high probability of negative influences on control. Among a lot of methods of adaptive control, it was verified that the self-tuning control provides acceptable results even in the case of nonlinear multivariable systems. Therefore this approach was used in this paper.

The usage of pre-identification helps to increase the accuracy. The control with pre-identification it is not so common such as adaptive control.

This paper combines the adaptive control with the pre-identification. When the reference signal changes, there will be a new model and identified data will be stored. The two tank model, which was used for verification, is a model with significant interactions caused in nature by the interconnection of the model.

The paper is organized as follows. Firstly, the introduction part is given. This is followed by two tank model description. After that, the used method of control is described in short. Finally, the results of real-time control of two tanks model in MATLAB are given, programming in MATLAB can be taught in several ways (Perutka & Heczko, 2007).

2. TWO TANKS MODEL DESCRIPTION

In figure 1, there is the scheme of the apparatus and its connection to PC. The apparatus is located in one of research laboratories at the Department of Process Control, Tomas Bata University in Zlin.

The tanks system consists of two interconnected measuring tanks. The water level is controlled by two pumps, each tank by one pump. The water level in each tank can be measured directly by ruler reading, there is the scale on each tank. Moreover, the water level is measured automatically using the capacitance sensors. The system has its own power supply of the control power supply voltage. The power supply is used for the circuits of pump amplifier and for the capacitance water level sensors.

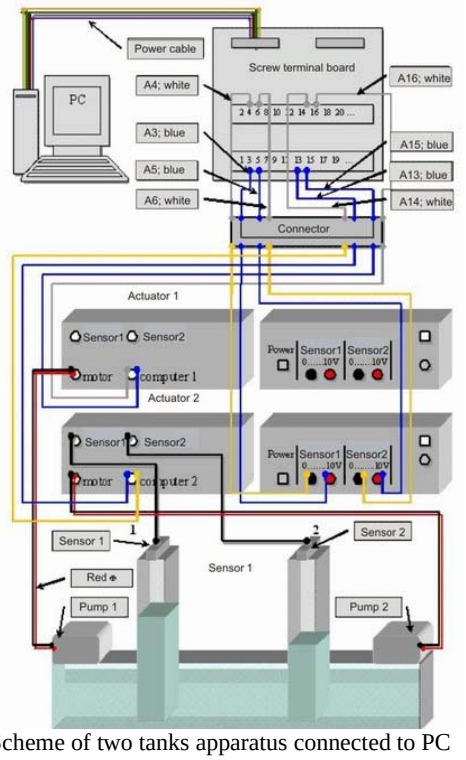

Fig. 1. Scheme of two tanks apparatus connected to PC

The wires from the tanks system are connected to the switchboard, from which the cable is connected to the technological card, which is mounted to the PC motherboard.

3. SHORT DESCRIPTION OF USED ALGORITHM

The two tanks model, which is a MIMO system, can be controlled by a set of single input single output controllers. The number of controllers is the same as the number of outputs or inputs of this MIMO system. In purpose to change the controller parameters on the influence of interconnections, the self-tuning control (STC) is used. The parameters of controller are counted using suboptimal linear quadratic tracking, which is used for instance by Perutka (Perutka, 2009). STC uses recursive instrumental variable method for estimating the continuous-time model of the subsystem. Derivation of input and output are taken as derivation of approximating regression Lagrange polynomials. They are necessary for identification. The first parameters estimates are obtained using the pre-identification. The purpose of pre-identification is that the controlled system is supposing to be completely identified before the control task starts. Therefore it is denoted as a pre-identification. During the pre-identification, the system to be controlled is viewed as "a black box" model and it is identified by direct and/or indirect continuous-time algorithms. The whole interval of control is divided into intervals based on the change of some of reference signals, each interval is identified separately. Each interval is identified several times, every time by different method of identification. Model obtained by identification method is separately compared with measured response. The parameters of model that are nearest to the measured data are used in control.

Two tanks system is divided in two SISO subsystems in purpose of control. Each subsystem employs the SISO controller, both subsystems run simultaneously. The apparatus is described by linear model with variable parameters in every time instant of at least one of set-point change, during the control the parameters of the used process model changes. This fact is caused by interactions among the subsystems, the change of control voltage of one pump influences the water level in both tanks.

4. RESULTS OF REAL-TIME CONTROL

In this chapter, the results of real-time control are going to be shown. The SIMULINK scheme was used for the real-time control of the two tanks system. In this scheme, there are also blocks from the real-time control toolbox library. As can be seen from the history of water level control, figure 2 and 3, the used method provides satisfactory results and can be used for such a type of process.

The quantities in the following figures are following. Figure 2: y_1 – output of first subsystem; w_1 – reference signal of first subsystem; figure 3: y_2 – output of second subsystem; w_2 – reference signal of second subsystem.

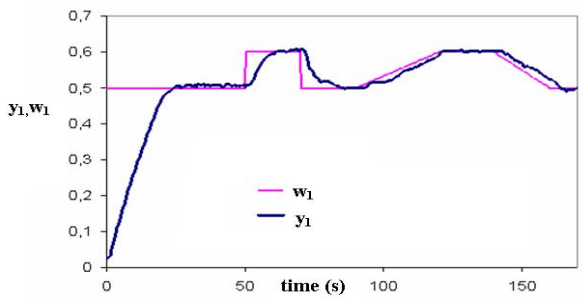

Fig. 2. History of water level control in first tank

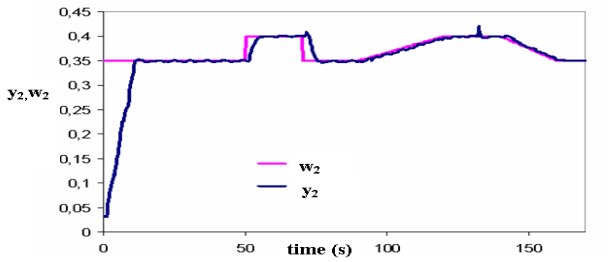

Fig. 3.History of water level control in second tank

5. CONCLUSION

In the paper, there was presented the real-time control with pre-identification of two tanks model, the apparatus in the laboratory. This approach was in the previous work applied on the simulation model only. The paper deals with the implementation of this method in the laboratory and in real-time for the first time. The presented results of control prove that the proposed approach of control can be used for control of two tanks model and similar devices. In future, the attention will be paid to implementation of other methods of control and identification and its verification in real-time in laboratory, and at another model, the helicopter.

6. ACKNOWLEDGEMENT

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