International Journal of Innovative Computing, Information and Control
Volume **3**, Number **2**, April **2007**

ICIC International ©2007 ISSN 1349-4198
pp. **419–434**

MULTILEVEL TECHNIQUE FOR LARGE SCALE LQR WITH TIME-DELAYS AND SYSTEMS CONSTRAINTS

Mohamed F. Hassan

Electrical Engineering Department
College of Engineering and Petroleum, Kuwait University
P. O. Box 5969, Safat 13060, Kuwait
mfahim@eng.kuniv.edu.kw

Kebir Boukas

Department of Mechanical Engineering
Ecole polytechnique de Montreal
P. O. Box 6079, Station centre-ville
Montreal, Quebec, H3C 3A7, Canada
el-kebir.boukas@polymtl.ca

Received January 2006; revised March 2006

Abstract. *This paper deals with the large scale discrete linear quadratic (LQ) problem with time delays and constraints on the states and controls. Under the assumption of the feasibility of the considered control problem, a new procedure based on multilevel control techniques is developed to solve this optimization problem. It is shown that with the proposed technique, it is neither required to increase the dimensionality of the system due to time delays, nor use extra multipliers to handle the system constraints. Our results are applied to a practical control problem to show the efficiency of the developed algorithm in getting the optimal solution with great saving in calculation time.*
Keywords: Large scale system, Constrained states and inputs, Time-delay systems

1. **Introduction.** Most practical control problems like those in process control are subject to constraints on states and/or controls due to physical limitations and/or to keep safe and acceptable systems operations. Moreover, some physical systems may have time delays in states and/or on control due to different phenomena like transmission lines for instance. The optimal control of this class of systems is challenging due to the difficulties and computational burden encountered in finding the optimal solution. The problem becomes much more difficult in cases of large scale systems.

Time delay systems can be handled using different approaches. Among these approaches are those using auxiliary variables to approximate time delay elements, then applying the well developed techniques to control the behavior of the extended system model [1,2,21,22]. The main disadvantage of this technique is that, it increases the dimensionality of the model, which depends on the value of the time delay, and may lead to an unstable model. Another class of approaches which can also be used with time delay systems is based on robust control techniques. In this case, controllers are designed to guarantee system stability. A lot of work was reported in the literature on this subject, among them we quote, for example, the works [3-6] and the references therein.