Contributed Session 6: Control and Optimization

Use of differential equations for mathematical description of water-supply network pumps drive system-simulation tests

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In the paper, application of differential equations in modelling and simulation tests of water-supply network pumps drive system together with the powered water-supply pipelines is presented. The description is preceded with an analysis of practically applicable mathematical models representing drive systems of that type. Models of electric devices and their elements, from the point of view of methods used to describe phenomena occurring in them, can be divided into three basic groups: circuit models, semi-field models, and field models. Each of the groups has its own purpose depending on complexity of the modelled electric system, type of devices, and required accuracy in reconstruction of processes actually occurring in the system. In the case under consideration, sufficient accuracy is ensured by circuit models. Mathematical models of PWM converter, squirrel-cage induction motor, and pump together with a pipeline, allow to carry out computer simulations of the whole drive system consisting of the above-listed elements. Simulations of the system of such complexity pose definitely more difficult problem than simulation of each of the elements performed separately. In the following, mathematical models of individual elements of the system are presented.

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Remarks and Results on Steering Solutions of Some Functional Differential Equations to a Desired State

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First, we comment on some serious problems in many published papers dealing with controllability of some functional differential equations in infinite dimension. Then, we give conditions of controllability for a class of neutral functional differential equations with infinite delay. Finally, we illustrate our abstract result by an example.

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On null controllability with vanishing energy

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Recent results on controllability with vanishing energy for linear control systems in Hilbert or Banach spaces were given by Priola and Zabczyk (SIAM J. Control Optim. (42) 2003) and Van Neerven (SIAM J. Control Optim. (43) 2004). We give new results for linear and semi linear systems in Banach spaces.

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Solve the Vehicle Routing Problem with Time Windows via a Genetic Algorithm

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The objective of vehicle routing problem (VPR) is to deliver a set of customers with known demands on minimum-cost vehicle routes originating and terminating at the same deport. A vehicle routing problem with time windows (VPRTW) requires the delivery made in s specific time window given by the customers. Prins (2004) recently proposed a simple and effective genetic algorithm (GA) for VPR. In terms of average solution cost, it outperforms most published tabu search results. We implement this hybrid GA to handle VPRTW. Both the implementation and computational results will be discussed.

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Robust ℓ-step receding horizon control of sampled-data nonlinear systems with bounded additive disturbances with application to a HIV/AIDS model

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In this paper, a robust receding horizon control for multirate sampled-data nonlinear systems with bounded additive disturbances is presented. Sufficient conditions are established which guarantee that the ℓ-step receding horizon controller that stabilizes the nominal approximate discrete-time model also practically stabilizes the exact discrete-time system with small disturbances. This

version of the method is motivated by recently developed models of the interaction of the HIV virus and the immune system of the human body. In this model the drug dose is considered as control input, and the uninfected steady state is to be stabilized. Reverse transcriptase inhibitors is used. Simulation results are discussed.

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Output feedback stabilization of sampled-data nonlinear systems by receding horizon control via discrete-time approximations

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This paper is devoted to the stabilization problem of sampled-data nonlinear systems by output feedback receding horizon control. The observer is designed via an approximate discrete-time model of the plant. We investigate under what conditions, this design achieve practical stability for the exact discrete-time model.

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Optimal Control of a Nonlinear Model of Economic Growth

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A nonlinear control model of a firm that describes the change of production and accumulated R&D investments is investigated. The difference between our model and the existing models is that our model considers the effect of absorption of innovations. Optimal dynamics of economic growth of a firm versus current cost of innovations is studied. An optimal control problem with the terminal functional and the rate of R&D investments as a control parameter is solved. It is analytically found that optimal control can have one of the following types: a) piecewise constant with at most two switchings or b) piecewise constant with a singular control. The intervals on which switching from regular to singular arcs occur are found. In order to investigate how our model depends on parameters, a new regularization algorithm is developed. Optimal investment strategies and production activities are compared with econometric data of a real firm.

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Geometric methods in nonlinear control synthesis for electro-hydraulic servoactuators

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Stability analysis for equilibria of nonlinear systems of differential equations modelling mechano-hydraulic servoactuators reveals the presence of unstable equilibria. The use of electro-hydraulic servoactuators, besides its main quality of integrating computers in high-accuracy applications, aims to ensure stability of the relevant closed-loop system's equilibria.

The mathematical models of electro-hydraulic servoactuators to be considered will consist of five-dimensional systems of control differential equations when servoelastic effects are neglected, or of seven-dimensional systems when these effects are taken into account. Methods from geometric control theory lead to synthesis of feedback controllers such that all relevant equilibria in the closed-loop system are stable. A particular feature of closed-loop systems that result from the synthesis above is the presence of a zero eigenvalue in the spectra of the Jacobian matrices calculated in equilibria. To handle this critical case for stability theory, a theorem of Lyapunov and Malkin is used.

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Global convergence of a memory gradient method with a closed-form stepsize formula

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The memory gradient method is used to solve large scale unconstrained optimization problems. We investigate a closed-form stepsize formula given by a finite number of iterates of Weiszfeld's algorithm to computer the stepsize for a memory gradient method. This formula can be classified as a no-line search procedure since no stopping criteria is involved to ensure convergence, unlike the classical line search procedures. The closed-form stepsize is proposed in ref[1] for conjugate gradient methods. We show the global convergence of the memory gradient method.

Ref[1]: Global Convergence of conjugate gradient methods with a closed-form stepsize formula.C.Labat, J.Idier, 2005.

Keywords: Memory gradient method, convergence, closed-form stepsize formula, Weiszfeld's algorithm

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The H-J equation of the minimal time function: the constant dynamic case

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In their recent papers [1] and [2], Clarke and Nour studied (using new methods from nonsmooth analysis) the Hamilton-Jacobi equation of the minimal time function in a domain which contains the target set. An important special case is the constant dynamic, that is, when the multifunction is taken to be a fixed set. The purpose of this paper is the application of these results to this special case. This application lets us (after giving some new geometric results) to present a geometric necessary and sufficient conditions for the existence of solutions to eikonal equations.

References:
[1] F. H. Clarke and C. Nour, The Hamilton-Jacobi equation of minimal time control, J. Convex Anal., 11 (2004), No. 2, pp. 413-436.
[2] C. Nour, Semigeodesics and the minimal time function, ESAIM: Control, Optimisation and Calculus of Variations, 12 (2006), pp. 120-138.

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The changes of air gap in inductive engines as vibration indicator aided by mathematical model and artificial neural network

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The method of analyzing vibration of electric engines or electromagnetic generators proposed in the work is based on the analyzing of course current of load. In considerations were used the method based on specialized mathematics model and advanced calculation technique. It allow to create of patterns for artificial neural networks. These patterns represented different states of machine for the diagnostic and they are enable to define precisely the changes caused by failure. The measurement signals contained informations about different states machine. Such approach is easy to algorithmization, enables permanently generated patterns and separately analyzes of particular types of failure machines. Additionally used radial artificial neural networks allow eliminated the necessity of digitalization of course current stator. In order to achieve bigger accuracy of required results the voting method was used. Received experiments showed that the designed architecture of the net enables to achieve good properties of generalization correct answer for entrance date which weren't a part of training process.

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