

SCIENTIFIC DISCUSSION

COMMENTS TO TWO PAPERS PUBLISHED IN "JOURNAL OF THEORETICAL AND APPLIED MECHANICS"*

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1. Introduction

The papers were presented at the 7th Congress on Theoretical and Applied Mechanics (1993), and JTAM is a suitable place for their publishing. In the same time the journal separating its responsibility with authors for the paper quality (the way of representation, correctness of results, and *etc.*), it is very regrettably that the papers are full with mistakes.

These comments are aimed only to point out some blunders, as in general there is no possibility to remove them. This negative work is produced absolutely in the interest of JTAM's readers.

2. Adaptive control

The problem of choosing control stabilizing a mechanical system to some time-varying configuration (in Lagrange variables) is completely solved, *e. g.*, in [3]. In the cited book it is noted that these forces do not depend on inertial characteristics of the system if the beforehand configuration is the frame origin. This fact means that the force are adaptive with respect to these characteristics. In general, it is hard to expect that the similar independence or adaptiveness takes place. Nevertheless this is the case if the structure of a system is given with unknown constant parameters [4].

* This work is partly supported by Bulgarian Scientific Fund under the Grant No MM 522/95.

These results should be high appreciated and widely popularized. In the same time it must be noted that they cannot be directly applied in *existing* mechanical systems of robots, as there are many restrictions on control forces (on their amplitude, power and *etc.*).

Let us correct solving this important problem as the author [1] made some unfortunate and easily corrigible mistakes in the assertions and proof Theorem 1. Hereafter we cite numbered objects from the corresponding papers without reservation.

Due to the used proof scheme the following assertion can be stated.

Theorem 1. Assume that 1. the positive definite matrix $A(q)$ is bounded along with its inverse in a neighbourhood of the given trajectory;

2. the matrix $C(q, \dot{q})$ is bounded in a neighbourhood of the time-varying configuration defined by the trajectory;

3. Matrix gains of feedback (5) are connected by relation (6) where the positive constant λ is arbitrary, the constant positive definite matrix K_d satisfying to the following condition (in a neighbourhood of the time-varying configuration)

$$k_1 E_n \leq K_d - \lambda A(q) - \frac{1}{4} C(q, \dot{q}) K_d^{-1} C^T(q, \dot{q}) \leq k_2 E_n$$

where k_1 and k_2 are some positive constant; E_n is the unit matrix.

Then the zero equilibrium of the closed-loop system (4) - (5) is exponentially stable (in a neighbourhood of the equilibrium).

The given form of the theorem conditions permits us to introduce correctly the square form estimations used by the author [1] for proving the theorem.

This result is very useful as it is the exponential stability that guarantees the system stability when there are bounded additive perturbations in the system under consideration. The last is well-known [5], that is why it is not necessary to repeat its proof.

Let us show that the result [4] (see formulae (17)-(18)) is true if the used functional matrix $Y(t, q, \dot{q}, \ddot{q}, \ddot{q}_r)$ is known and sufficient representative in order to introduce a linear parameterization with some constant parameter p according to formula (16).

Indeed, introduce the new control $u_{id} = Y(t, q, \dot{q}, \ddot{q}, \ddot{q}_r) (p - v)$ and the indirect control

$$\frac{d}{dt}(p - v) = u_1.$$

Then the control u_1 can be defined by using the Lyapunov function used in proving Theorem 1 if the term $v^* v$ is added in this function.

It is easy to see that the last equation is equivalent to the next one (remind that p is a constant vector)

$$\dot{v} = -u_1.$$

That is why with the help of a routine technique we have

$$u_{id} = Y(t, q, \dot{q}, \ddot{q}_r) \int_0^t Y^*(\tau, q, \dot{q}, \ddot{q}_r) (e + \lambda \dot{e}) d\tau.$$

Thus the author [1] abused using some special terms (predictive control, estimations, quasiparameters, inverse dynamic model and *etc.*) as there is only a combination of feedbacks and indirect controls of the kind $u = u_{fd} + u_{id}$ ensuring the asymptotical trend of the Lagrange variables to the time-varying configuration.

3. Principal mistakes in [1]

Let us turn to that is marked by the author [1] as good results while it is incorrigible blunders:

- The simplifying of $Y(t, q, \dot{q}, \ddot{q}_r)$ suggested by the author [1] cannot be motivated by assertions of the kind “The redundancy implies that among the solutions there exist slowly varying ones” (page 41). That is why, in general, using the simplified matrix Y_d is unfounded. It can be true in particular cases for some narrow class of systems where it must be expected that the matrix $Y(t, q, \dot{q}, \ddot{q}_r)$ coincides with Y_d (at least, the fact that this class is wider is not obvious).
- The suggested estimating of matrix gains in feedback (25) is unfounded as the method of analogy cannot be used as a proof, namely: the above constructed indirect control is a result of using the corresponding Lyapunov function while in the case of the matrix gain estimating there is not such function. Besides, it is hard to understand the reason of introducing the integral term in the framework of the described scheme of solving the adaptive control problem.

At last the examples given say nothing about asymptotical properties of synthesized control systems while they are the aim of the author’s paper.

4. Principal mistakes in [2]

Turn to paper [2]. Its matter is less interest than [1] while the mistakes are more than obvious:

- Passing to “decouple” control system is accomplished with the great violation of the fact that the classical mechanics does not deal with the forces depending on accelerations. That is why this passing has no mechanical meaning, synthesized systems are not a subject of mechanics, and it is necessary to prove specially that they can be put in practice. This approach generates the following questions: How can the highest derivative be introduced in a control law (with the help of a special device, computing or approximation)?

How does the way of introducing influence on the desired properties of synthesized systems?

No answer on similar questions no guarantee of the desired properties.

- The local estimation (Theorem 1[2]) compares integral curves of two differential equations with the same initial data over the sample interval. Saying nothing about their divergence on the set of sample intervals, it is introduced incorrectly as initial data are same only in the initial point of sampling. Moreover it is hard to understand why it is introduced, as there it is only one important problem, namely, sampling terms that decouple the system under consideration.

Note it is absolutely nonsense to introduce any estimations of two different differential equations over a fixed subinterval of the interval where the existence and uniqueness theorems are true if there is no condition on the corresponding constants from the obtained estimation. It is clear that these estimation can be represented as arbitrary functions from any variables (*e. g.* from the sample interval length).

- Theorem 2 states the absurd assertion that under the formulated conditions the solution of equation (6) with fixed initial data will not increase over some fixed interval. In particular these conditions are true for the following equation $\ddot{x} + 3\dot{x} + 2x = 0$. It has the complex spectrum and thus the oscillation behaviour of integral curves.

At last, according to the above observations the examples given generate more questions than answers.

5. Conclusion

The mentioned mistakes are not removable and are multiplied in many works of the authors and especially in PhD theses (where the problems under consideration are main). It being not so important whether these works are fulfilled with mathematical mistakes, it is more important that there are neither proper settings of the problems under consideration nor their solving.

Acknowledgement

The author gratefully acknowledges many stimulating discussions with Prof. L. Lilov and Prof. S. Radev.

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