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CONTROVERSY

ON THE OBJECTIVITY OF SCIENTIFIC CITATION

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Abstract. The problem of citation objectivity is considered as a part of the general problem of creating scientific information environment. Examples confirming the importance of this problem are given. It is shown that the lack of objectivity in citation is related not only to the language barrier but also to certain subjective considerations.

Keywords: citation assessment of publications, parameterization of the set of stabilizing regulators, linear-quadratic control problem.

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1. Introduction

The problem of establishing the scientific priority of results is not new (see, e.g., the discussion between Gauss and Legendre concerning the authorship of the method of least squares in [52]).

However, the citation problem became actual only in the second half of the twentieth century. At this time, such questions as “the ethics of citation and other sociological problems” [46, Chapter 5, Section 6] have been widely discussed. Questions related to citation were considered in detail in the works [17–23, 50] devoted to the problem of the creation of the world-wide scientific information space. The point is that, as mentioned in [18], parameters related to citation are becoming increasingly popular, and they are extensively used in various spheres to assess the efficiency of scientists’ activity [18].

Moreover, according to Chairman of the Research Policy Committee of the universities of the United Kingdom Professor E. Thomas, beginning in 2008, numerical estimations of citations (bibliometric valuation) are used in planning research financing. Thus, citation assessment affects already the budget of science and education [21].

In this connection, the problem of citation objectivity is of special importance. This is testified by the discussion held in July, 2007, in the electronic journal *iMechanica, Web of mechanics and mechanicians* (http://imechanica.org/) on the server of the Harvard School of Engineering and Applied Sciences [22].

The topic of the discussion was “Objective citation – a proposal from the Timoshenko Institute.”

This discussion has confirmed the following theses [17].

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1. The problem of *ensuring the objectivity of journal publications* exists and is actual .
2. In the formation of scientific information environment, citation objectivity is the *feeblest component.*
3. Approaches to ensuring citation objectivity in journal publications *have not been developed* enough.

In [17], these theses were illustrated by examples showing that some results published in *International Journal of Solids and Structures* in 2002 and 2006 were obtained as early as 20–35 years ago and had already been published in *International Applied Mechanics*; moreover, the results published earlier (in 1971–1986) were given in more general setting. The mentioned 2002–2006 publications in *International Journal of Solids and Structures* did not refer to the results published earlier in *International Applied Mechanics* [22].

These examples witness that, even in the new millennium, information on the priority of scientific results was distorted.

This conclusion is also confirmed by [2, 5, 6, 8, 26, 30–32], where various examples witnessing the existence of the citation objectivity problem are given. Thus, [6] points out the absence of a reference to Reyleigh's classical result, [41] states the absence of references to more general results, and so on. We do not discuss these publications in what follows; the reader can find them at the journal sites.

Let us consider the situation related to the publication [54] where the problem of parameterization of a set of stabilizing regulators is considered.

2. The history of the question

In [54], the key relation of modern frequency methods of synthesis was given (in the opinion of the authors of [16], "this is a fundamental characterization of all stabilizing controllers and is the most useful result in frequency domain synthesis of linear systems"), namely, a parameterization of a set of regulators ensuring the stability of an object–regulator closed loop system.

It should be mentioned that, the publication [54] has 288 citations (SCOPUS 12.05.2010 database) and still retains its importance (see Table 1 containing the number of citations in various years and Table 2, in which some journals and conference proceedings in which this publication was cited are specified).

Year	2010	2009	2008	2007	2006
Number of publications	2	19	20	21	21

Table 1.

International Journal of Control	29
IEEE Transactions on Automatic Control	26
Automatica	23
Proceedings of the IEEE Conference on Decision and Control	21
Proceedings of the American Control Conference	19

Table 2.

Thus, [54] contains an important scientific result. However, from the point of view of citation objectivity, it should be mentioned that the parameterization procedure in question (see Sections

2 and 3 for a more general setting) was first proposed in [40, 42] (see [48] and discussions in [7, 29]); the scalar version of this parameterization was given in [44]. Note that the parameterization of [41] was described not only in Russian-language monographs [2, 13, 41, 42] (which have been given to USA Congress Library) but also in English-language publications [3, 9, 25, 34, 37-39] reviewed in *AMS Mathematical Reviews* and *Zentralblatt MATH* and in the English-language monograph [10], which was reviewed in English-language journals (see, e.g., [47]).

Noteworthy, the English-language publication [43] mentioned above, was reviewed in *Zentralblatt MATH* (Zb10269.93077) and appeared earlier than [54].

Below, following [11, 12], we expose the essence of the parameterization procedure and show how to derive the parameterization of [54] from that of [41].

3. Parameterization [41] of stabilizing regulators in the continuous-time problem

We describe the parameterization procedure of [41] for the stationary LQG problem (see, e.g., [13, Chapter 5; 24]). Below we use the designations followings [24]. As is known, in the control problem for a multidimensional stationary linear system, the control object can be described in various ways, in particular, by state-space equations

$$\dot{x} = Fx + Mu, \quad y = Lx,$$

(see relations (1a) and (1b) in [24, Chapter 8]) or by the transfer function between the input and the output represented in the form of the "ratio" of two polynomial matrices (matrix-fraction description (MFD)) as

$$D_L\,(d/dt)\,y = N_L\,(d/dt)\,u, \tag{1}$$

or

$$\begin{aligned} D_R\,(d/dt)\,\xi &= u, \\ y &= N_R\,(d/dt)\,\xi \end{aligned}$$

(see relations (2), (3a), and (3b) in [24, Chapter 8]). Here, x is the phase vector, u is a control, y is the vector of observed coordinates, ξ is the vector of intermediate variables, F, M, and L are constant matrices, $D_L(\cdot)$ and $D_R(\cdot)$ are invertible polynomial matrices, $N_L(\cdot)$ and $N_R(\cdot)$ are polynomial matrices of appropriate size. In terms of transfer functions, formally replacing d/dt by s (see polynomial matrix-descriptions in [24]), we obtain a relation between the input and the output in the form

$$\begin{aligned} y &= L\,(Es - F)^{-1}\,Mu, \\ y &= D_L^{-1}(s)N_L(s)u, \\ y &= N_R(s)D_R^{-1}(s)u. \end{aligned} \tag{2}$$

Hereinafter, E denotes the unit matrix. For simplicity, we sometimes omit the argument s below.

Thus, suppose that the motion of the control object is described by a system of ordinary differential equations similar to (1) of the form

$$Px = Mu + \psi, \tag{3}$$

where x is an n-vector, u is the m-vector of control action, ψ is an n-dimensional stationary random process with zero mathematical expectation and rational fractional matrix S_ψ of spectral densities, P and M are, respectively, $n \times n$ and $n \times m$ matrices, whose elements are operator polynomials in d/dt. The n-vector

$$y = x + \varphi \tag{4}$$

can be observed. In (4), φ is the vector of measurement errors, whose components φ_i $(i = 1, \dots, n)$ are stationary random processes with zero mathematical expectation and spectral density matrix S_φ. It is required to find a regulator equation

$$W_0 u = W_1 y \tag{5}$$

such that the corresponding closed loop system is stable (all zeros of the characteristic determinant of the system (3), (5) belong to the left half-plane) and the functional

$$I = \langle x' R x\rangle + \langle u' C u\rangle \tag{6}$$

takes its minimum in stable regime. In (5) and (6), W_0 and W_1 are matrices of proper size whiose elements are operator polynomials in d/dt, R and C are weight matrices, and $\langle\cdot\rangle$ denotes mathematical expectation. Consider the transfer matrix functions F_x^ψ, F_u^ψ, F_x^φ, and F_u^φ in

$$\begin{bmatrix} x \\ u \end{bmatrix} = \begin{bmatrix} F_x^\psi & F_x^\varphi \\ F_u^\psi & F_u^\varphi \end{bmatrix} \begin{bmatrix} \psi \\ \varphi \end{bmatrix},$$

which, according to (3)–(5), are defined by

$$F_x^\psi = (P - MW)^{-1}, \; F_u^\psi = W\,(P - MW)^{-1},$$
$$F_x^\varphi = F_x^\psi P - E, F_u^\varphi = F_u^\psi P. \tag{7}$$

Here, $W = W_0^{-1} W_1$. Since the closed loop system must be stable and, therefore, the elements of the matrices F_x^ψ, F_u^ψ, F_x^φ, and F_u^φ must have no poles in the right half-plane, it follows that the functional has the form

$$I = \frac{1}{i}\int_{-i\infty}^{i\infty} tr\,\left[\left(F_{x*}^\psi\, R F_x^\psi + F_{u*}^\psi C\, F_u^\psi\right) S_\psi + \left(F_{x*}^\varphi\, R F_x^\varphi + F_{u*}^\varphi C\, F_u^\varphi\right) S_\varphi\right] ds. \tag{8}$$

Hereinafter, the subscript " * " denotes transposition and the replacement of the argument s by $-s$, and tr denotes the trace of a matrix. Thus, the synthesis problem under consideration reduces to finding a matrix W for which the closed loop system is stable and the functional (6) reaches its minimum. In this context, the variations δW arising in the minimization of the functional (8) are constrained so that the corresponding variations $\delta F_x^\psi, \delta\, F_u^\psi$, δF_x^φ, and δF_u^φ of the matrices F_x^ψ, F_u^ψ, F_x^φ, and F_u^φ have no poles in the right half-plane, i.e., are physically realizable (the physical realizability of the weight and transfer functions is understood in the sense of Wiener; i.e., a physically realizable weight function equals to zero at $t < 0$, and, accordingly, a physically realizable transfer function is an analytic function in the right half-plane [53] or a filter transfer function of the second kind [15]).

According to (7), the physical realizability of the functions F_x^ψ and F_u^ψ and their variations implies physical realizability of the functions F_x^φ and F_u^φ and their variations δF_x^ψ and δF_u^ψ. Considering (7), we obtain

$$P F_x^\psi - M F_u^\psi = E. \tag{9}$$

Hence, the $n(m+n)$ elements of the matrices F_x^ψ and F_u^ψ can be expressed in terms of $m+n$ independently varying functions. Consider the $m \times n$ matrix Φ defined by

$$A F_x^\psi + B F_u^\psi = \Phi, \tag{10}$$

where A and B are polynomial matrices of proper size. We have

$$F_x^\psi = P^{-1} + P^{-1} M \left(B + A P^{-1} M\right)^{-1} \left(\Phi - A P^{-1}\right), \tag{11}$$

$$F_u^\psi = \left(B + A P^{-1} M\right)^{-1} \left(\Phi - A P^{-1}\right). \tag{12}$$

It follows from (7) and (9)–(12) that

$$\Phi\,(P - MW) = A + BW, W = F_u^{\psi}(F_x^{\psi})^{-1}.$$

Consequently, the matrix of the transfer function of the regulator is defined by

$$\mathrm{W} = (\mathrm{B} + \Phi\mathrm{M})^{-1}\,(\Phi\mathrm{P} - \mathrm{A}). \tag{13}$$

Rewriting (9) and (10) in the form

$$Z\begin{bmatrix} F_x^{\psi} \\ F_u^{\psi} \end{bmatrix} = \begin{bmatrix} E \\ \Phi \end{bmatrix}, Z = \begin{bmatrix} P & -M \\ A & B \end{bmatrix}, \tag{14}$$

we see that if the matrices A and B ensure the absence of the poles of the matrices Z and Z^{-1} in the right half-plane, then the physical realizability of the variations δF_x^{ψ} and δF_u^{ψ} implies that of the variation of the matrix Φ, and vice versa. Let us determine under what conditions (13) can be considered as a parameterization algorithm for the set of all regulators stabilizing the object (3). In other words, we seek conditions on the matrices A and B under which the stability of the closed loop system (the physical realizability of the matrices F_x^{ψ} and F_u^{ψ}) implies the physical realizability of the matrix Φ and the latter implies the stability of the object–regulator closed loop system. According to (10), the first requirement is met, because matrices A and B are polynomial and, consequently, have no poles in the right half-plane. To check the second, we use the left MFD of the matrix Φ, that is,

$$\Phi \;=\; \Gamma^{-1}\,\Pi, \tag{15}$$

where Γ and Π are polynomial matrices and, moreover, $\det\Gamma$ is a Hurwitz polynomial or a constant. Substituting (13) and (15) into (14), we obtain

$$(\Gamma\mathrm{B} \;+\; \Pi\mathrm{M})\mathrm{u} \;=\; (\Pi\mathrm{P} - \Gamma\mathrm{A})(\mathrm{x} \;+\; \varphi).$$

Thus, the motion of the closed loop system (3), (5) is described by the equations

$$\begin{bmatrix} E & 0 \\ \Pi & \Gamma \end{bmatrix}\begin{bmatrix} P & -M \\ A & B \end{bmatrix}\begin{bmatrix} x \\ u \end{bmatrix} = \begin{bmatrix} \psi \\ (\Pi P - \Gamma A)\,\varphi \end{bmatrix},$$

whose characteristic determinant is equal to $\det\Gamma\cdot\det Z$. Thus, the physical realizability of the matrix Φ (for which $\det\Gamma$ is a Hurwitz polynomial) implies the stability of the closed loop system, provided that detZ is a Hurwitz polynomial, i.e., Z^{-1} has no poles in the right half-plane. In other words, the necessary and sufficient condition for relation (13) to determine a parameterization of a stabilizing regulator is that the polynomial matrices A and B must be chosen so as to ensure the analyticity of Z^{-1} in the right half-plane. Decomposing the matrix Z^{-1} into blocks as

$$Z^{-1} = \begin{bmatrix} \theta_{11} & \theta_{12} \\ \theta_{21} & \theta_{22} \end{bmatrix} \tag{16}$$

and taking into account the equality

$$(\Phi\mathrm{P} - \mathrm{A})(\theta_{11} + \theta_{12}\Phi) \;=\; (\mathrm{B} + \Phi\mathrm{M})\;(\theta_{21} \;+ \theta_{22}\;\Phi)$$

(which follows from the condition $ZZ^{-1} = E$), we obtain the following parameterization of W similar to (13) (provided that $\det(\theta_{11} + \theta_{12}\Phi)$ is not identically zero):

$$\mathrm{W} = (\theta_{21} + \theta_{22}\Phi)\;(\theta_{11} \;+ \theta_{12}\;\Phi)^{-1}. \tag{17}$$

4. The parameterization of [54]

In [54], it was proposed to parameterize the matrix W as follows (see relation (34) in [54]):

$$\mathrm{W} \;=\; -\,(\mathrm{Y}\;+\;\mathrm{D_R}\,\Phi)\,(\mathrm{X}\;-\;\mathrm{N_R}\,\Phi)^{-1}, \tag{18}$$

where the polynomial matrices X and Y satisfy the Diophantine equation

$$\mathrm{PX} + \mathrm{MY} = \mathrm{E} \tag{19}$$

and the matrices N_R and D_R are the components of the right MFD representation of the matrix $\mathrm{P}^{-1}\mathrm{M}$:

$$\mathrm{P}^{-1}\mathrm{M} = \mathrm{N_R} D_R^{-1}.$$

In other words, $P = D_L$ and $M = N_L$ in (19). Let us analyze the relationship between the parametrizations (13), (17) and (18), (19). According to Lemma(6.3.9) in [24] (on the direct and inverse Bezout identities), there exist polynomial matrices V_R, U_R, V_L, and U_L such that

$$\begin{bmatrix} V_R & U_R \\ N_L & -D_L \end{bmatrix} \begin{bmatrix} D_R & V_L \\ N_R & -U_L \end{bmatrix} = \begin{bmatrix} E & 0 \\ 0 & E \end{bmatrix}, \tag{20}$$

or

$$\begin{bmatrix} D_L & -N_L \\ U_R & V_R \end{bmatrix} \begin{bmatrix} V_L & N_R \\ -U_L & D_R \end{bmatrix} = \begin{bmatrix} E & 0 \\ 0 & E \end{bmatrix} \tag{21}$$

In other words, the matrices

$$Z = \begin{bmatrix} D_L & -N_L \\ U_R & V_R \end{bmatrix}, \qquad Z^{-1} = \begin{bmatrix} V_L & N_R \\ -U_L & D_R \end{bmatrix} \tag{22}$$

are polynomial and, consequently, all θ_{ij} $(i,j = 1,2)$ in (16) have no poles in C_+. C_+ denotes the right half-plane. Using relations (20) and (21), we can determine the relationship between the parameterizations (13), (17) and (18), (19). Thus, taking U_R and V_R for the matrices A and B, i.e., determining the matrices A and B from the Diophantine equation

$$\mathrm{AN_R}\;+\;\mathrm{BD_R}\;=\;\mathrm{E}, \tag{23}$$

we see that, according to (22), $\theta_{11} = V_L$, $\theta_{12} = N_R$, $\theta_{21} = U_L$, and $\theta_{22} = D_R$. Substituting these expressions into (17), we conclude that under the above choice of the matrices A and B, the parameterization (18) and (17) (the latter is equivalent to (13)) differ only in the sign of the matrix Φ. This means that the parameterization (18) is a particular case of the parameterization (13). It should be mentioned that parameterization (13) applies also to more general synthesis problems, in particular, to problems in which the motion of an object is described by delay differential equations [2, 11-13, 42].

5. Citation questions

In our opinion, the situation in the citing the result of [41] is a good illustration of the theses of [17] given in the introduction. In this case, it is hard to attribute the lack of objectivity in citation solely to the language barrier. Indeed, in spite of the fact that the parameterization procedure proposed in [41] was published in Russian-language press (including the leading Soviet journal *Doklady Akademii Nauk SSSR* [40]), one of the authors of this paper was had to publish the letter [29]. We quote this letter below, because it characterizes the situation fairly adequately: "We welcome the publication of the paper [51], which is written at a high professional level and devoted to one of the modern directions of frequency methods of synthesis. I agree with the authors' opinion that, in control theory, a new promising scientific direction is being developed; but, for readers' information, the following remark should be made. The key relation of the frequency methods of synthesis, which is the parameterization (2) in [51] (in the opinion of the authors of [16], this is the most useful result of the theory of frequency synthesis of linear systems (see the comments to (9) in [16]), is attributed to the authors of [54] in the English-language literature. As mentioned in [48] (see comments to (35) in [48]), this relation first appeared in [41], and we pay attention to this fact (see [35] for a more detailed comparison of results obtained in [41] and elsewhere)." Note that the authors of [51] have not respond to the letter [29]. The situation in the English-language literature appears to be similar to that described above. Thus, in the 2007 paper [7], an argument similar to that of [29] was exposed. Nevertheless, in 2009, the same journal (*IEEE Trans. Automat. Control*) published the paper [45] containing a reference to [54] and no reference to [41]. To conclude, we mention the "most recent" publications [4] as an illustration to the citation objectivity problem. We give an abridged (examples are omitted) quotation from [4]: "In [49], the special cases of the linear quadratic problem when the poles of external perturbations lie on the imaginary axis are considered. In this analysis, the frequency domain method and Youla, Jabr and Bongiorno Jr. [54] parameterizations are used. In other words, the case was considered when the investigated characteristic polynomial of the closed loop system has roots on the imaginary axis. It is necessary to note that such problems (problems of servosystem synthesis, problems of pursuit-evasion), when the characteristic polynomial of the closed-loop system has zero roots, were considered in ([42] (Examples I–III §2, Ch. V). Moreover, in ([42], (Example II §3, Ch. V) the problem of pursuit–evasion was formulated for the objects with delay. In this case, the procedure of parameterization (concerning the parameterization in [41] and [54], see ([7, 11, 12]) was used. In such problems the state space method was used as well. Cases when Hamiltonian matrix has zero and imaginary eigenvalues (see the examples resulted below) have been considered in ([3, 27, 36]). The same problem was stated in Item 1.4 of "Linear Quadratic Problem with Singular Hamiltonian Matrix" by Aliev and Larin [10], and this fact does not correspond to the statement by Park and Bongiorno Jr [49]: "…Aliev and Larin (1998) also suffer from some limitation" (see Example 1). It is known, that to one of procedures of rational matrices is the factorization procedure. In [28], the algorithm factorization of rational matrices with zero and on an imaginary axis poles is presented. Let us note that in a number of the problems similar to the considered in [49], case the usage of the mentioned procedures of the state space method can be effective. Thus, absence of the works [3, 7, 11, 12, 27, 28, 36, 41, 42], in the list of references of [49], from our point of view, is regretful." The response [14] contained, in particular, the following: "It is indeed regretful that several of the references cited in the comments by Aliev and Larin are not included in Park and Bongiorno Jr [49] and that the statement about the implied limitations of Aliev and Larin [10] was not made clearer. However, this has provided an opportunity for the publication of their comments and this response. The monographs Larin, Naumenko, and Suntsev [41, 42] contain significant insights and accomplishments with regard to the frequency domain design of linear multivariable systems with feedback. They represent a notable achievement for their time: a key contribution, the parameterisation of all stabilising controllers, preceded the one presented in Youla, Jabr, and Bongiorno Jr [54]. A more recent and modern presentation of the ideas contained in these works is included in Aliev and Larin [10] ... ".

6. Conclusion

The examples considered above confirm the thesis of [21] that "in procedure of citing and its estimations the narrowest and undeveloped moment is maintenance of objectivity of citing and novelty of the obtained results".

We emphasize that the lack of objectivity in citation is not always caused solely by the language barrier.

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