Report

of dissertation council member **Hu Guang-Da** on the PhD thesis presented by **R.A. Sevostyanov** "Multipurpose Control of the Moving Plants Considering Delay", submitted for the Candidate of Physical and Mathematical Sciences degree with specialization 2.3.1. System analysis, control and information processing, statistics

Control systems synthesis is a central problem in the modern control theory. Despite the numerous methods already developed, harsher requirements and constraints arising from the production and logistics needs define the necessity of continuous research of new approaches. One significant requirement is caused by the fact that modern control systems are implemented on the digital board hardware. Its digital nature is the source of the control signal delays which usually cause negative effects to the motion dynamics. Therefore the delay compensation is one of the most important problems in control theory.

Another noticeable modern feature is usage of images from the board videocameras in order to improve control dynamics quality. Visual information can be used either to estimate plant's current position or as a direct feedback input. For example, in autonomous docking problem it might be enough just to provide the desired position of some visual marker projection in the image plane.

Stabilization of the moving plants considering a set of requirements to the motion dynamics with delay compensation and visual information is the core problem considered in the presented thesis. As it was stated before, this is quite actual problem in the current research with many applications in different fields of the modern robotics and vehicle autopilot. New methods are obtained showing that it is enough to synthesize the feedback providing desired dynamic characteristics for the system without the delay first and then to transform the obtained regulator to achieve delay compensation.

The manuscript consists of 132 pages divided into four chapters.

Chapter 1 considers the basic problem of the motion stabilization with delay compensation. A special multipurpose control structure is introduced which is capable of satisfying a set of dynamic requirements in different operating modes. A discretization of the obtained feedback is described which can be directly implemented on the board hardware.

In Chapter 2 the dynamic visual positioning problem is researched. Here the author also uses multipurpose regulator in the task of positioning the plant in front of the visual marker. Two algorithms were developed for the feedback synthesis: one without the delay and another for delay compensation. Efficiency of the proposed approach is illustrated with the results of the computer simulation with two types of mobile robots.

Chapter 3 is devoted to the problem of motion stabilization of the nonlinear systems which can be linearized using special feedback which compensates nonlinearities (so-called feedback linearization method). Two algorithms were also developed here with and without the delay. The results of the two-link robot manipulator computer simulation are provided to demonstrate the performance of the described algorithms.

In Chapter 4 the air cushion vehicle motion stabilization problem is considered. Nonlinear and linearized dynamic models are provided. The process of the multipurpose regulator syntehsis with delay compensation is described and supplemented with the plots of computer model dynamics of the air cushion vehicle.

The presented results are given on a high quality level. 17 papers on the thesis topic were published, 5 of them are indexed in Scopus and Web of Science CC. The text of the dissertation is well organized and clearly written. All the theorems and conclusions are provided with strict proofs and explanations.

Nevertheless, the following remarks can be formulated:

1. Seems like the delay compensation requires knowledge of the precise mathematical model and delay value. What if we have only rough estimates of them? Will it worsen the closed loop dynamics?

2. In the Theorem 3.1 it is assumed that the external disturbance in the linearized system is constant. But it can be seen that this disturbance actually depends on plant state and on the external disturbance for the original nonlinear system. So even if the latter is constant, any plant motions leads to non-constant disturbance for the linearized system. How is the feedback working in this case then?

Despite the above mentioned remarks, the thesis clearly merits to be positively evaluated.

The thesis of R.A. Sevostyanov "Multipurpose Control of the Moving Plants Considering Delay" fulfills the requirements established in the decree 19.11.2021 № 11181/1 on "Order of Granting Degrees in St. Petersburg State University". R.A. Sevostyanov deserves to be granted with the degree of Candidate of physical and mathematical sciences (Specialization 2.3.1. System analysis, control and information processing, statistics). Clause 11 of the said decree has not been violated by the candidate for the degree.

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