DESCRIPTION FOR THE GENERAL PUBLIC

Members of the Institute of Automatic Control of the Silesian University of Technology observed that most of the phenomena they are working on can be described with the following scheme: there is a given object we can influence by means of quantities called controls or inputs. In response to them, the object returns signals called outputs. The outputs and controls are indirectly connected by quantities called states. This forms a typical control theory scheme. However, some important recent findings of control theory have not yet been applied in these domains.

The main research hypothesis states that it is possible to effectively analyse models, which are composed of partial differential equations, delayed systems and jump systems, and that this analysis including stability, controllability, stabilizability, sensitivity and optimality of control of these models will increase, in a large extent, possible applications of control theory, and will make contribution to the development of state of the art of dynamical systems.

In automatic control the first step in solving the problem of reaching desired system behaviour is to build a mathematical model, which, by means of appropriate mathematical formulae, describes the relations between controls and outputs in the object. As they are problem-related, the controls and outputs may have a significantly different character, e.g. be scalars, finite or infinite dimensional vectors, sets etc. To find the relations between controls and outputs two main approaches are used. The first one, called physical, engages known laws of physics to find the relations of interest. The second one, called the black box method, is based on tuning parameters of initially selected model in order to obtain a highly similar response between controls and outputs in object and its representing box. In these identification experiments a carefully selected control signals are fed to the object and its model, and their responses are observed. In engineering practice those two approaches are frequently used together. In the first step the physical laws are engaged to discover the type of the object, e.g. linear ordinary differential equation with periodical coefficients. The second step is to determine the values of those coefficients.

When creating a model of a physical process simplifications are frequently necessary. Their purpose is to obtain a model, which can be further processed by means of available theoretical tools. This approach inevitably leads to discrepancies in model and object behaviour. Recent modelling tasks challenge scientists with the need of finding process relations in a very precise manner. It results in reaching for very intricate models, being the combinations of partial differential equations, delayed systems, jump parameter systems, descriptor or fractional systems. We reach a state where the necessity of using of combinations of above types arises e.g. infinite dimensional systems described by delayed fractional equations with jump parameters.

The analysis of dynamical properties of such combined complex mathematical models is indispensable and, at the same time, it is an innovation on its own merit. It should be underlined that reaching for such complex models is not just a result of scientific curiosity and willingness to examine their properties. It has a very solid justification in the possibility of application of control theory results and methods in description and analysis of interdisciplinary engineering problems. To many of those problems the ideas from control theory have not yet been applied because of the inability to describe them with currently available models.

The fundamental problems considered in control theory, which will be scrutinized in the case of analysed models are: qualitative analysis; sensitivity analysis; optimal control.

Each of above properties is of crucial importance to every practical system. For this reason solving above problems for dynamical systems considered in this application has a ground-breaking potential in effective solving of similar practical problems a will form a basis to many innovative future applications.

In the project, after analysis of theoretical properties resulting models will be applied to the description of problems tackled previously by other methods by members of the Institute of Automatic Control of the Silesian University of Technology. This includes human musculoskeletal system and noise and vibration reduction.