Research project objectives

The objective of this research is twofold, first to provide a theoretical analysis of the fractional-order switched systems (FOSS) and second, to apply control systems consisting of fractional-order controllers with switched dynamics. Derivatives and integrals of non-integer order, often referred to as fractional, are natural extensions of the standard integer-order ones. Fractional derivatives are non-local operators and, unlike integer-order ones, they cannot be evaluated at a given point by mere knowledge of the function in a neighborhood of this point. In fractional systems, the dynamics does not only depend on the present state value but also on its past values, which has many significant consequences for the behavior of systems.For that reason, fractional systems are suitable for describing phenomena with memory or long-range of interaction in space and/or time. Switched systems are successfully used for modelling real-life systems that are so complex that, not one, but several dynamical subsystems are required to describe their behavior, which may depend on various factors. Switched systems consist of a finite number of subsystems and a logical rule that orchestrates switching between these subsystems. The analysis and design results of switched systems showed that they are very helpful in dealing with real systems, especially in the control strategy for nonlinear or nonstationary plants.

Motivation and expected results

The aim of this research is to bring together fractional-order systems and switched systems. This is a new topic in the control systems theory and so far has not been explored in a comprehensive way. To the best of authors knowledge, literature concerning FOSS is not vast. As the real phenomena are more accurately described by the fractional-order systems, it is expected that FOSS will be more efficient than integer-order switched systems. Therefore, there appears a strong need for research in the area of FOSS. One may expect that dynamical properties of FOSS such as stability, stabilization by the state and output feedback, controllability, observability as well as many other properties are more complex and difficult than those of integer-order. Therefore, finding the solutions to mentioned problems will be challenging, but can lead to useful and practical results, particularly in intelligent control design. Considered class of systems is interesting, especially in the view of control systems synthesis, where e.g., the dynamic behavior of the controller depends on the switching function. This idea explicitly exhibits new possibilities in the controller designing process, e.g., for nonlinear or nonstationary plants, where the parameters of a fractional controller may be changed during the process according to the state of the plant. The presented project will contribute to the development of the research methodology for the analysis and synthesis of selected classes of linear and nonlinear FOSS.

Research methodology

Theoretical research with the use of computer calculations including simulation studies will be conducted. Results will have a form of precise statements expressed with the aid of mathematical language. Most results will be accompanied by rigorous proofs. Where possible, the proofs will be constructive, equipped with algorithms, which allow later for efficient checking the conditions from the statements. The algorithms will form a basis for the software development that will allow to use computers in practical verification of conditions. For controllers tuning, nonlinear optimization algorithms will be implemented. Practical implementation and real-life tests will require a DAQ card and/or PLCs. Computer calculations will be made in the Matlab/Simulink or Maple environment. LabView software connected with PXI computer capabilities will be used for the implementation and verification of known and project-developed control methods. Collected data will be processed and stored in the repository.