

Research project objectives/ Research hypothesis

Positive systems are dynamical or control systems for which the variables take nonnegative values. There will be considered analytic systems, with finite-dimensional state spaces, on arbitrary time scales. A time scale is a model of time. Time may be continuous, discrete or mixed. Continuous- and discrete-time systems will be considered as particular cases.

Some of the main problems considered in the project will be stability and stabilizability of positive nonlinear systems. Stability is the property of the system to return to its equilibrium, and stabilizability is a possibility of obtaining a stable system with the aid of feedback. The systems will be described by delta differential equations, which, depending on the used time scale, will have the form of differential or difference equations. One of the objectives of the project will be characterization of stability, asymptotic stability and feedback stabilizability. These properties will have a slightly different meaning than for systems without positivity property, since trajectories will start only from positive cone of the state space. Criteria of stabilizability will be accompanied by constructions of feedbacks that stabilize the systems. Relations between stabilizability and controllability for this class of systems will also be investigated.

The next goal of the project will be checking which properties of positive nonlinear continuous-time systems are preserved under discretization. Both Euler discretization, related to numerical solutions of differential equations, and sampling, applied for digital control of continuous-time systems, will be considered. Since the discretization step will possibly be nonconstant, this transformation will transform continuous-time systems onto systems on nonhomogeneous discrete time scales. Invariance of different types of stability, stabilizability, controllability, observability and realizability of response maps will be studied.

The last goal of the project will be application of the obtained results to construction of control schemes for concrete systems that appear in biology, medicine and robotics. In particular, systems modeling tumor therapy will be studied.

The subject of positive systems is interesting from the theoretical point of view and because of numerous applications. The theoretical aspect is related to quaint properties of positive systems and special mathematics used to study such systems. A possibility of applying theory of positive systems to modeling real systems in biology and robotics causes that these studies seem to be more important than other studies for which it is difficult to find applications.