Automatic Control Theory

Study programme: N0714A270012 Control of Machines and Processes
Academic year: 2024/2025

1. Control theory and its relation to cybernetics (basic types of control, structures of control systems, sensitivity of control systems with open and closed structure, control robustness).
2. Mathematical models of one-dimensional linear dynamic systems (steady state, feasibility, relations, minimum phase, time delay and its approximation).
3. Experimental identification based on step responses (measuring, evaluation, Strejc´ method, one-point and two-point approximations, responses to impulse or ramp function).
4. ARX and ARMAX mathematical models (determination its coefficients by the method of one-time identification and continuous identification, exponential forgetting).
5. Linear continuous and digital controllers (PID and PSD controllers, properties, realisations, absolute and relative control algorithms, anti-windup, degree of freedom).
6. Performance of continuous and digital linear one-dimensional control systems (time domain, complex variable domain, frequency domain, steady state error determination).
7. Synthesis of one-dimensional continuous and digital control systems (chosen experimental and analytical methods, the choice of sampling period, direct approach to digital controller design).
8. SISO advanced linear discrete and continuous control systems (with auxiliary controlled variable (cascade), with disturbance variable measurement, with auxiliary manipulated variable, Smith and modified Smith predictor, internal model control).
9. Mathematical models of multi-dimensional linear dynamic systems (transfer matrix, basic connections, feasibility, relations, minimum phase).
10. Stability checking and synthesis of multi-dimensional linear continuous and digital control systems (characteristic equation, stability criteria, autonomy, invariance).
11. Mathematical models of nonlinear continuous systems (the common nonlinearities, the basic connection of static nonlinearities).
12. The stability checking of nonlinear systems (the Lyapunov stability definition, Lyapunov Direct and Indirect method, Popov criterion, Circle criterion).
13. Analysis in state/phase plane, the Describing Function method (equilibria, limit cycles, determination of phase trajectories, finding the describing function, stable and instable limit cycles).
14. The extremum seeking control (with the derivation of the output according to the input, with the derivative of the output by time, with memory, with periodic signal, with a step change of the action variable).
15. Fuzzy Control (Fuzzy sets, the basic operations with fuzzy sets, Fuzzification and Defuzzification, the basic structure of Fuzzy controller).
16. State space model of linear continuous dynamic systems, stability, controllability and observability.
17. The basic canonical form of state space model, transformation to canonical form.
18. State space control and Luenberger observer for linear dynamical systems. Integral state space control.

19. Single-variable unconstrained optimization (NC, SC, NSC, analytical methods and numerical methods).
20. Multivariable optimization (unconstrained problems – NSC, Sylvester's criterion, constrained problems in the form of equality – Lagrange function, Lagrange multipliers and their interpretation, constrained problems in the form of inequality – Kuhn-Tucker conditions).
21. Graph theory (basic concepts, assignment of tasks, types of graphs, Eulerian graph, Hamiltonian cycle, methods for finding the shortest path).
22. Dynamic optimization (types of optimization tasks with fixed or free final state and time, basic forms of functional, tasks of optimal control, types of optimal control).
23. Necessary conditions for the existence of minimum of objective functional for dynamic programming (Bellman function, BPDE, necessary and sufficient conditions). Pontryagin's minimum principle, Calculus of variations.
24. The State Variables Aggregation Method (standard form, non-robust and robust control, sliding mode control).
25. Neural Networks (structure, parameters, topology, learning, perceptron NS – backpropagation algorithm).
26. Neural Networks (perceptron NN and convolutional NN – topology, activation functions, types of layers, learning process, applicability).

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