Control theory - course description

General information

Course name	Control theory
Course ID	06.0-WE-AutD-ConTheory-Er
Faculty	Faculty of Computer Science, Electrical Engineering and Automatics
Field of study	Automatic Control and Robotics / Computer Control Systems
Education profile	academic
Level of studies	Second-cycle Erasmus programme
Beginning semester	winter term 2020/2021

Course information

Semester	1
ECTS credits to win	5
Course type	obligatory
Teaching language	english
Author of syllabus	• dr hab. inż. Wojciech Paszke, prof. UZ

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Laboratory	30	2	-	-	Credit with grade

Aim of the course

1. To recognize the basic description methods of nonlinear control systems.

2. To familiarize students with analysis and synthesis methods for continuous-time control systems based on Lapunov's theory.

3. To familiarize students with the methods of formulating and solving optimal control problems.

Prerequisites

Mathematical analysis, Linear algebra, Control Engineering

Scope

Introduction to nonlinear systems. The most common nonlinear systems. The state space representation. An equilibrium point. Typical behaviour of nonlinear systems. Limit cycles.

Analysis of dynamic properties of nonlinear systems with the phase plane method. The second order nonlinear systems; graphical representation with phase portraits. Singular points. Graphical and numerical methods for generating of a phase portrait. Stability analysis of nonlinear systems by using the phase plane method.

Stability analysis. Different definitions to a nonlinear system stability. Lyapunov's linearization method. Lyapunov's second (direct) method. Global asymptotic stability analysis. La Salle's theorem. Stability of time-varying nonlinear systems. Instability theorems. Absolute stability criterions. A sector nonlinearity. Popov and circle criterion. Controller synthesis based on Lyapunov's method.

The describing function method. Definitions of a limit cycle and characteristics. The existence theorem. Definition of the describing function. Describing function for systems with input saturation, output deadzone and hysteresis respectively. Using the describing function method for limit cycle analysis. Stability analysis of a limit cycle.

Feedback linearization. Mathematical basics of feedback linearization. Lie's algebra. Input-output linearization. Linearization conditions. *Controllability conditions*. Algorithm for an input-state linearization. Normal forms. Diffeomorphism. Algorithm for an input-output linearization. Internal dynamics. Asymptotic properties of nonlinear minimum phase systems.

Teaching methods

Lecture, laboratory exercises.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
Has knowledge on the impact of non-linearity on static and dynamic characteristics of systems.		• a quiz • an ongoing monitoring during classes	• Laboratory
Ability to reduce the task of optimal control to the problem of mathematical programming		• a quiz • an ongoing monitoring during classes	• Laboratory

Outcome description	Outcome symbols	Methods of verification	The class form
Ability to analyze the stability and controller synthesis with Lapunov methods		• an exam - oral, descriptive, test and other • an ongoing monitoring during classes	• Lecture • Laboratory
Has knowledge on the basic methods of stability analyzis for nonlinear systems		• an exam - oral, descriptive, test and other	• Lecture

Assignment conditions

Lecture – obtaining a positive grade in written or oral exam.

Laboratory – the main condition to get a pass is scoring sufficient marks for all laboratory exercises.

Recommended reading

1. D. Atherton, An introduction to Nonlinearity in Control systems, Ventus Publishing, 2011.
2. H. K. Khalil, Nonlinear Systems, 3rd edition, Prentice Hall, 2002.
3. S. Skogestad, I. Postlethwaite: Multivariable feedback control. Analysis and design. John Wiley and Sons, 2nd edition, 2005.
4. P. Albertos, A. Sala : Multivariable control systems: An engineering approach, Springer, London, 2004.
5. K.J. Åström, R.M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, Princeton, 2009

Further reading

Notes

Modified by dr hab. inż. Wojciech Paszke, prof. UZ (last modification: 29-04-2020 21:16)