GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Control Structures and Algorithms, PG_00038316		
Field of study	STRUKTURY I ALGORYTMY STEROWANIA		
Date of commencement of studies	February 2025	Academic year of realisation of subject	2025/2026
Education level	second-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	2	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Control Systems Engineering -> Faculty of Electrical and Control Engineering -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Tomasz Rutkowski	
	Teachers	dr inż. Tomasz Rutkowski dr inż. Tomasz Zubowicz dr inż. Bartosz Puchalski mgr inż. Mateusz Czyżniewski	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	15.0	0.0	0.0	0.0	45

E-learning hours included: 0.0

eNauczanie source address: https://enauczanie.pg.edu.pl/2025/course/view.php?id=917

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	45	10.0	45.0	100

Subject objectives

Acquiring a knowledge related to advanced control methods and algorithms enabling the construction of such control structures that will allow for effective control of linear/nonlinear objects, both single and multidimensional.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_K04] is able to react in abnormal and emergency situations, health and life-threatening when use of automation and robotics components and systems	Student is able to propose basic actions in emergency situations related to the operation of the control structures used, in accordance with safety principles and applicable procedures.	[SK1] Ocena umiejętności pracy w grupie [SK3] Ocena umiejętności organizacji pracy
[K7_U10] is able to apply the known mathematical tools and methods and computer techniques to analyse and evaluate automation and robotics components, devices, systems and systems	The student can conduct the synthesis of the known advanced control algorithms for a given object specification. The student designs and implements control structures using the known advanced control methods and algorithms.	[SU1] Ocena realizacji zadania [SU3] Ocena umiejętności wykorzystania wiedzy uzyskanej w ramach przedmiotu [SU4] Ocena umiejętności korzystania z metod i narzędzi [SU5] Ocena umiejętności zaprezentowania wyników realizacji zadania
[K7_W06] has an extended knowledge of the design of automation components and devices, control and decision support systems control and decision support systems and complex mechatronic systems	The student uses known (learned during the classes) methods and advanced control algorithms in the projects of control systems.	[SW1] Ocena wiedzy faktograficznej

<table>
<tr><td>Subject contents</td><td>Course content – lecture
Control structures, methods and algorithms for control and state estimation: Kalman filters (assumptions, disturbances and measurement noise, a recursive form of the estimator); predictive control algorithms DMC, QDMC, GPC (problem formulation, a model for prediction, stability, implementation aspects); linearization by feedback (input-state linearization, input-output): differential-integral calculus of fractional orders (definitions of fractional-order operators, approximations of fractional-order operators, fractional-order PID controllers); variable structure control, sliding mode control (stability of sliding motion and conditions of its existence, control law, consideration of various aspects of uncertainty, a continuous approximation of the control law); intelligent adaptive neural and object fuzzy control with nonlinear dynamics with unavailable state and uncertainty in object model dynamics. Application of Linear Matrix Inequalities (LMI) in the synthesis of control systems.

Course content – exercises

Tutorials cover the practical implementation of the following topics:

• Estimation of the linear state of an object with distortions and measurement noise with a temporal structure using the Kalman Filter method,
• Synthesis of follow-up manipulator control (robot arm) realizing the reference movement trajectory by linearization method by feedback with nonlinearity leakage compensation in conditions of viscous friction and additive disturbances,
• Synthesis, implementation and verification of fractional-orders PID controllers for selected linear objects,
• Implementation and verification of DMC and QDMC predictive control algorithms for selected single and multidimensional linear objects,
• Implementation and verification of the sliding mode control algorithm enabling the stabilization of a nonlinear object with disturbances in internal dynamics.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td></td></tr>
<tr><td>Assessment methods and criteria</td><td>
<table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Class tests</td><td>50.0%</td><td>50.0%</td></tr>
<tr><td>Tutorial reports</td><td>50.0%</td><td>50.0%</td></tr>
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<tr><td>Recommended reading</td><td>
<table>
<tr><td>Basic literature</td><td>1. Franklin G. F., Powell J.D., Abbas Emami-Naeini: Feedback Control Dynamic Systems. Sixth Edition, Pearson, Upper Saddle River, 2010.
2. Slotine Jean Jacques E., W. Li: Applied Nonlinear Control. Prentice Hall, Englewood Cliffs, New Jersey 07632, 1991.
3. Brdys Mietek A., Tatjewski P.: Iterative Algorithms for Multilayer Optimizing Control, Imperial College Press, World Scientific Publishing Co. Pte. Ltd., 2005.
4. Rawlings J.B., Mayne D.Q.: Model Predictive Control: Theory and Design. Nob-Hill Publishing, 1st edition, 2009.</td></tr>
<tr><td>Supplementary literature</td><td>1. Khail Hassan K.: Nonlinear Systems. Prentice Hall, Englewood Cliffs, New Jersey 07632, 2002.
2. Maciejowski J.M.: Multivariable Feedback Design. Addison Wesley, 1989
3. Byrski W.: Obserwacja i Sterowanie w Systemach Dynamicznych. Uczelniane Wydawnictwa Naukowo Dydaktyczne Akademii Górniczo Hutniczej w Krakowie, 2007 (Control and Estimation in Dynamical Systems)
4. Tatjewski P.: Sterowanie Zaawansowane Obiektów Przemysłowych struktury i algorytmy. Warszawa, Akad. Oficyna Wyd. EXIT, 2002. (Advanced Control of Industrial Processes Structures and Algorithms)
5. Duda J. T.: Modele Matematyczne, Struktury i Algorytmy Nadrzędnego Sterowania Komputerowego. Uczelniane Wydawnictwa Naukowo Dydaktyczne Akademii Górniczo-Hutniczej w Krakowie, Kraków, 2003. (Mathematical Models, Structures and Algorithms for Supervisory Computer Control)</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
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<tr><td>Example issues/ example questions/ tasks being completed</td><td>• Present the structure of the Kalman Filter and describe its properties.
• Describe the concept of linearization by feedback methodology.
• Introduce the concepts of the predictive control algorithm.
• Identify the similarities and differences between the DMC and QDMC predictive control algorithms.
• Identify the similarities and differences between GPC and QDMC predictive control algorithms.
• Describe the concept of sliding mode control.
• Describe the chosen method of approximating the fractional-order operators.</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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