GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Artificial Intelligence in Civil Engineering, PG_00069220		
Field of study	Civil Engineering		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2026/2027
Education level	first-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	4	Language of instruction	Polish
Semester of study	7	ECTS credits	5.0
Learning profile	general academic profile	Assessment form	assessment

Conducting unit	Department of Engineering Structures -> Faculty of Civil and Environmental Engineering -> Faculties of Gdańsk University of Technology	
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Patryk Ziółkowski
	Teachers	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	30.0	0.0	0.0	0.0	45
	E-learning hours included: 0.0						
	eNauczanie source address: https://enauczanie.pg.edu.pl/moodle/course/view.php?id=29772						

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	70.0	125

Subject objectives	The objective of the *Artificial Intelligence in Civil Engineering* course is to provide students with fundamental knowledge and practical skills in applying artificial intelligence and machine learning methods to solve problems in civil engineering. The course prepares students to independently carry out simple AI/ML projectsfrom data preparation and programming environment configuration, through model training, validation, and evaluation, to interpreting results in an engineering context. Students will acquire competencies valued in modern construction practice, such as engineering data analysis, prediction of structural parameters, automation of diagnostics, and the use of programming tools to solve practical industry challenges.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_K04] Engages in independent lifelong learning and individually follows the development of science and technology in the field of civil engineering.	Upon completing the course, the student demonstrates readiness for independent and lifelong learning in the field of artificial intelligence in civil engineering, actively follows new tools, algorithms, and technological developments, and is able to independently experiment with them to solve engineering problems.	[SK5] Assessment of ability to solve problems that arise in practice
[K6_K03] Can effectively, clearly and unambiguously convey information, describe activities and communicate their results/ outcomes to engineers or a wider audience using appropriate communication methods and tools.	Upon completing the course, the student is able to clearly, effectively, and professionally communicate the results of applying artificial intelligence methods in civil engineering—both in written form (technical report, project documentation) and oral form (presentation). The student uses appropriate communication tools and adapts the message to audiences such as engineers or the general public.	[SK2] Assessment of progress of work

Subject contents	Course content – lecture The lecture component covers theoretical concepts related to artificial intelligence and machine learning, as well as their applications in civil engineering, aligned with the course modules: 1. **Introduction to AI/ML in Civil Engineering** definitions, importance of AI, practical applications: drone image analysis, settlement prediction, material usage forecasting. AI as an engineering tool. 2. **Typical ML tasks and AI project stages** regression, classification, clustering; ML workflow: data collection, preprocessing, training, validation, interpretation. 3. **Machine learning techniques algorithm overview** linear regression, logistic regression, k-NN, decision trees, SVM, multilayer perceptron. Conceptual understanding and engineering examples (e.g., compressive strength prediction). 4. **AI tools and environments** Python, ML libraries (scikit-learn, TensorFlow, DEAP), environment configuration, and tools supporting data visualization and model training. 5. **Engineering data processing and analysis** data cleaning, detection of measurement errors, statistical analysis, interpretation of plots. Importance of data quality in AI projects. 6. **Structural optimization with AI** genetic algorithms, optimization of cross-sections, reinforcement, cost, and material usage; swarm intelligence concepts. Case studies. 7. **Structural diagnostics using image analysis (CV)** convolutional neural networks (CNN), detection of cracks, corrosion, and material degradation. Practical examples and limitations. 8. **Critical thinking and the engineers role in AI projects** limitations of AI, importance of engineering judgment, expert involvement in automated decision-making. Course content – exercises Laboratory classes focus on practical implementation of lecture content through hands-on work with engineering datasets, algorithm development, and semester project execution: 1. **Workshop 1: Environment setup and programming basics** Installation and testing of Python environment (Anaconda, Jupyter, Google Colab), import of libraries (NumPy, Pandas, scikit-learn, TensorFlow), basic test scripts; Python syntax, data structures, control statements. 2. **Workshop 2: Data preparation and exploratory data analysis (EDA)** Loading engineering datasets, data cleaning (handling missing values, outliers), interpolation, encoding, scaling; statistical analysis and data visualization (histograms, scatter plots, boxplots). Preparation of training and test sets. 3. **Workshop 3: Model training regression and classification** Implementing ML models (linear regression, decision trees, k-NN); training/test split; calculation of metrics (MSE, RMSE, accuracy, confusion matrix); interpretation of results, discussion of cross-validation and hyperparameter tuning. Kick-off of team projects. 4. **Workshop 4: Project presentations and course summary** Team presentations: project goal, data, applied methods, results and interpretation, conclusions. Discussion, evaluation of solutions, feedback, and further development recommendations.
Prerequisites and co-requisites	No formal prerequisites are required. Basic knowledge of mathematics, particularly linear algebra and statistics, is recommended. Programming skills are not requiredthe course includes an introduction to the basics of programming in Python.
Assessment methods and criteria	see table below

Subject passing criteria	Passing threshold	Percentage of the final grade
	60.0%	40.0%
	60.0%	60.0%

<table>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>The core reading list includes scientific publications, educational materials, and documentation of tools used in the course, based on the instructional documentation. Key sources include:
1. Mohammed Rady, Application of evolutionary algorithms to design economic flat slab buildings based on the intended function, Scientific Reports, vol. 14, Art. 8826, 2024.
2. M.A. Nyathi, J. Bai, I.D. Wilson, Deep Learning for Concrete Crack Detection and Measurement, Metrology, 4(1): 6681, 2024.
3. Instructor-prepared materials: notes, exercise instructions, sample datasets, and Jupyter notebooks (e.g., DataCleaning.ipynb).
4. Documentation of AI/ML libraries: scikit-learn, TensorFlow, PyTorch (available online).</td></tr>
<tr><td>Supplementary literature</td><td>• M. D. Wilkinson et al., The FAIR Guiding Principles for scientific data management and stewardship, Scientific Data, 2016.
• E. E. Ambarita et al., Industrial digital twins in offshore wind farms, Energy Informatics, 2024.
• V. Leble et al., Data exchange formats, HYBRID WIND Project, Work Package 1 - Deliverable D1.2, 2025.
• A. Michiorri et al., Topic Taxonomy and Metadata to Support Renewable Energy Digitalisation, Energies, 2022.
• DCMI Metadata Terms, Dublin Core Metadata Initiative, 2020.
• Course e-learning materials: multimedia, case studies, Python notebooks, lab instructions, and sample datasets (e.g., DataCleaning.ipynb).</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table>

Example issues/ example questions/ tasks being completed	1. Explain the difference between supervised, unsupervised, and reinforcement learning provide examples of applications in civil engineering. 2. Load a real dataset on concrete compressive strength, clean missing and outlier values, perform exploratory data analysis (EDA), and present conclusions. 3. Compare linear regression and decision tree models for predicting concrete strength interpret the results (MSE, R^2). 4. Design a simple classification model for crack detection on concrete images discuss data preparation and appropriate evaluation metrics. 5. Define an optimization problem for a reinforced concrete element propose decision variables and constraints for a genetic algorithm. 6. What are the key stages of an AI/ML project? Indicate which stages may be most challenging in engineering applications and why. 7. Develop a short technical report summarizing model training results include result interpretation and practical implications. 8. Analyze generated detection results for damage on a concrete slab image identify true damage areas versus noise. 9. What is the engineers role in AI-based design? Why cannot the engineer be fully replaced by an algorithm? 10. Prepare a team presentation on an AI application in civil engineering include objective, data, method, results, conclusions, and recommendations.
Practical activites within the subject	Not applicable

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