Basic Linear Geostatistics

Course description sheet

Basic information

Field of study Geospatial Computer Science **Major** - **Organisational unit** Faculty of Geo-Data Science, Geodesy, and Environmental Engineering **Study level** First-cycle (engineer) programme **Form of study** Full-time studies **Profile** General academic	**Didactic cycle** 2022/2023 **Course code** DGEIS.li20.06399.22 **Lecture languages** English **Mandatoriness** Elective **Block** Elective Modules in Foreign Language **Course related to scientific research** Yes

Course coordinator	Marcin Ligas
Lecturer	Marcin Ligas

Period	**Method of verification of the learning outcomes**	**Number of ECTS credits**
Semester 6	Completing the classes **Activities and hours** Lectures: 15 Project classes: 15	3

Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
Knowledge – Student knows and understands:			
W1	definitions and concepts related to the fundamentals of theory of regionalized variables.	GEI1A_W05, GEI1A_W06	Execution of a project, Test

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
W2	fundamentals of geostatistical analysis and interpretation of results.	GEI1A_W05, GEI1A_W06	Activity during classes, Test, Project
Skills – Student can:			
U1	propose a mathematical model representing a given spatial phenomenon.	GEI1A_U03, GEI1A_U04	Activity during classes, Test, Project, Case study
U2	perform geostatistical analysis on his own and to interpret and present the results	GEI1A_U03, GEI1A_U04, GEI1A_U10, GEI1A_U13	Activity during classes, Execution of a project, Test, Project
U3	geostatistical software for modeling and interpreting spatial phenomena	GEI1A_U03, GEI1A_U10	Activity during classes, Execution of exercises, Execution of a project
Social competences – Student is ready to:			
K1	work in a team, use geostatistical methods to solve problems from other scientific disciplines and is aware of the importance of constant improvement of the language in terms of professional terminology	GEI1A_K01, GEI1A_K03	Activity during classes, Participation in a discussion, Involvement in teamwork, Presentation

Program content ensuring the achievement of the learning outcomes prescribed to the module

This course is intended to give a student a basic insight into specific probabilistic models and corresponding statistical methods for spatial data.

Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	15
Project classes	15
Preparation for classes	11
Realization of independently performed tasks	14
Examination or final test/colloquium	2
Preparation of project, presentation, essay, report	18
Student workload	**Hours** 75
Workload involving teacher	**Hours** 30

* hour means 45 minutes

Program content

No.	Program content	Course's learning outcomes	Activities
1.	Introductory stage: reminder of statistics (expected value, variance, correlation coefficient, linear regression), matrix algebra and systems of equations Computation of empirical semivariogram and covariance function in 1D case (e.g. for time series) and in 2D case (for spatial data), manual and least squares fitting of an authorized model, computation of practical range, interpretation of semivariogram parameters Exact prediction in standard formulation of kriging predictor. Filtered prediction. Differences between the two as to the predicted values and kriging variance. Geostatistical software: Geostatistical Analyst (ArcGIS extension), R - CRAN packages dedicated to kriging prediction	U1, U2, U3, K1	Project classes
2.	Introduction to Geostatistics, notion of a random field, Matheron's theory of regionalized variables, main fields of application. Stationarity assumptions (second order stationarity and intrinsic stationarity), covariance function and semivariogram, relation between semivariogram and covariance function for second order stationary spatial processes Estimation of empirical semivariogram, theoretical semivariogram models, semivariogram fitting, semivariogram parameters (nugget effect, partial sill, sill and range of autocorrelation) Spatial prediction and filtering by means of ordinary kriging Quality control of kriging parameters - crossvalidation	W1, W2, U1	Lectures

Extended information/Additional elements

Teaching methods and techniques :

Case study, Discussion, Lectures

Activities	Methods of verification	Credit conditions
Lectures	Activity during classes, Execution of a project, Test, Project, Case study	
Project classes	Activity during classes, Participation in a discussion, Execution of exercises, Execution of a project, Test, Project, Case study, Involvement in teamwork, Presentation	

Conditions and the manner of completing each form of classes, including the rules of making retakes, as well as the conditions for admission to the exam

Attendance at lectures is not compulsory but it is strongly encouraged. If a student has received a failing grade and has not completed the course in a primary term, he or she may be reassessed twice. A make - up assessment will have a written form and will encompass the entire presented material. The lecturer sets proper terms and conditions of reassessment.

Method of determining the final grade

Student has to pass all tests (weight 0.6) and complete assignments (weight 0.4). The final grade will be the weighted average.

Manner and mode of making up for the backlog caused by a student justified absence from classes

The way and mode of catching up on project classes resulting from the student's absence will be determined individually.

Prerequisites and additional requirements

Basics of mathematics and statistics. Intermediate level of English is required. The knowledge of basic English terminology in statistics will be appreciated.

Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lectures: Studenci uczestniczą w zajęciach poznając kolejne treści nauczania zgodnie z syllabusem przedmiotu. Studenci winni na bieżąco zadawać pytania i wyjaśniać wątpliwości. Rejestracja audiowizualna wykładu wymaga zgody prowadzącego. Project classes: Studenci wykonują prace praktyczne mające na celu uzyskanie kompetencji zakładanych przez syllabus. Ocenie podlega sposób wykonania projektu oraz efekt końcowy.

Literature

Obligatory

1. Armstrong M., 1998, Basic Linear Geostatistics, Springer
2. Isaaks E.H., Srivastava R.M., 1990, An Introduction to Applied Geostatistics, Oxford University Press
3. Leuangthong, O., Khan, D., and Deutsch, C.V., 2008, Solved Problems in Geostatistics, Wiley Interscience
4. Olea R.A., 2006, A six-step practical approach to semivariogram modeling, Stochastic Environmental Research and Risk Assessment, 20(5), 307-318

Scientific research and publications

Publications

1. Ligas M., Kulczycki M., (2010), Simple spatial prediction – least squares prediction, simple kriging, and conditional expectation of normal vector, Geodesy and Cartography, 59 (2), 69–81.
2. Ligas M., Kulczycki M., (2017), Kriging and moving window kriging on a sphere in geometric (GNSS/levelling) geoid modeling, Survey Review, http://dx.doi.org/10.1080/00396265.2016.1247131.
3. Lenda G., Ligas M., (2012), Application of splines supported by kriging for precise shape analysis of incompletely measured structures, Journal of Computing in Civil Engineering, 26 (2), 214–224.
4. Ligas M., Kulczycki M., (2014), Kriging approach for local height transformations, Geodesy and Cartography, 63 (1), 25–37.
5. Ligas M., Szombara S., (2018), Geostatistical prediction of a local geometric geoid – kriging and cokriging with the use of EGM2008 geopotential model, Studia Geophysica et Geodaetica, https://doi.org/10.1007/s11200-017-0713-7

Learning outcomes prescribed to a field of study

Code	Content
GEI1A_K01	samodoskonalenia, a także postępowania profesjonalnego, odpowiedzialnego i zgodnego z zasadami etyki zawodowej; prawidłowej identyfikacji i rozstrzygania dylematów związanych z wykonywaniem zawodu.
GEI1A_K03	podejmowania prostych zadań inżynierskich jako etapu bardziej złożonych przedsięwzięć z uwzględnieniem nakładu pracy i kosztów ich realizacji; aktywnego i kreatywnego współdziałania w zespole.
GEI1A_U03	pozyskiwać i integrować dane przestrzenne oraz automatyzować te procesy, a także wykorzystywać i automatyzować wybrane metody analiz dla celów modelowania i rozwiązywania problemów inżynierskich.
GEI1A_U04	formułować i rozwiązywać zadania przestrzenne i inżynierskie, posługując się zaawansowanymi metodami analitycznymi, symulacyjnymi i eksperymentalnymi, w tym implementować adekwatne algorytmy obliczeniowe.
GEI1A_U10	pozyskiwać informacje z literatury, baz danych i innych źródeł oraz dokonywać ich interpretacji, a także wyciągać wnioski oraz formułować i uzasadniać opinie; posługiwać się językiem obcym w stopniu wystarczającym (na poziomie B2) do porozumiewania się, a także czytać ze zrozumieniem nieskomplikowane teksty naukowe i techniczne.
GEI1A_U13	przygotować i przedstawić krótką prezentację ustną poświęconą wynikom realizacji powierzonego zadania w tym przeprowadzić debatę.
GEI1A_W05	podstawowe zasady konstruowania algorytmów z wykorzystaniem technik algorytmicznych oraz analizy złożoności algorytmów, a także metody automatyzacji przetwarzania danych pozwalające na rozwiązywanie zagadnień geoinformatycznych i inżynierskich.
GEI1A_W06	podstawowe zasady tworzenia i wykorzystania baz danych, w tym baz danych przestrzennych oraz systemów zarządzania nimi; podstawy modelowania i wizualizacji obiektów i zjawisk przestrzennych.