AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Analysis of nonstationary signals

Academic year: 2019/2020 Code: ZSDA-3-0250-s ECTS credits: 6

Faculty of: Szkoła Doktorska AGH

Field of study: Szkoła Doktorska AGH Specialty: —

Study level: Third-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 0

Course homepage: —

Responsible teacher: dr hab. Dudek Anna (aedudek@agh.edu.pl)

Module summary

The student will acquire knowledge and skills in the analysis of cyclostationary and almost cyclostationary signals, having numerous applications in telecommunications, mechanics, vibroacoustics and economics. In addition, the student will acquire skills in using various bootstrap methods and applying them to construct confidence intervals for the characteristics of these processes.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Skills: he can			
M_U001	Student is able to analyze cyclostationary and almost cyclostationary series in the time and frequency domain	SDA3A_U01, SDA3A_U02	Completion of laboratory classes
M_U002	Student is able to judge his/hers degree of understanding of the problem and to point out the missing elements of reasoning, he/she is able to look for solution in the recent scientific publications	SDA3A_U01	Execution of laboratory classes
M_U003	Student is able to choose the appropriate method of analysis for considered real data of a nonstationary nature, he/ she knows how to look for solutions in scientific publications on the problem under consideration	SDA3A_U01	Completion of laboratory classes
Knowledge: he knows and understands			
M_W001	Student knows the basic concepts and theorems of the theory of nonstationary time series with a periodic and almost periodic structure	SDA3A_W01	Examination

M_W002	Student knows the basic resampling methods for nonstationary data	SDA3A_W02	Execution of laboratory classes
M_W003	Student knows the most important consistency results for resampling methods for nonstationary data	SDA3A_W02	Examination

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
60	30	0	30	0	0	0	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Skills: he can												
M_U001	Student is able to analyze cyclostationary and almost cyclostationary series in the time and frequency domain	-	-	+	-	-	-	-	-	-	-	-
M_U002	Student is able to judge his/hers degree of understanding of the problem and to point out the missing elements of reasoning, he/she is able to look for solution in the recent scientific publications	-	-	+	-	-	-	-	-	-	-	-
M_U003	Student is able to choose the appropriate method of analysis for considered real data of a nonstationary nature, he/ she knows how to look for solutions in scientific publications on the problem under consideration	-	-	-	-	-	-	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	Student knows the basic concepts and theorems of the theory of nonstationary time series with a periodic and almost periodic structure	+	-	+	-	-	-	-	-	-	-	-

M_W002	Student knows the basic resampling methods for nonstationary data	+	-	-	-	-	-	-	-	-	-	-
M_W003	Student knows the most important consistency results for resampling methods for nonstationary data	+	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	60 h
Preparation for classes	35 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	20 h
Realization of independently performed tasks	30 h
Examination or Final test	2 h
Contact hours	3 h
Summary student workload	150 h
Module ECTS credits	6 ECTS

Additional information

Module content

Lectures

A reminder of the basic concepts of stationary series analysis.
strong and weak stationarity, trend, seasonality, autocovariance, ARMA models

Spectral analysis of stationary time series.
Herglotz’s theorem, spectral density function – examples, interpretation, estimation

Cyclostationary series - introduction. Spectral analysis of cyclostationary series.
definition of the periodic process, examples, applications in telecommunications and mechanics, basic characteristics, Fourier representation of the autocovariance function, the impact of various operations on periodic series, spectral density.

PARMA time series
definition of periodic ARMA model, discussion of all stages of the PARMA series analysis

Generalizations of cyclostationary series.
almost periodically correlated time series, generalized almost periodically correlated time series, their characteristics and basic definitions

Introduction to resampling methods. Bootstrap for independent data.
idea of bootstrap, consistency for the overall mean, examples of inconsistency, second order correctness

Bootstrap confidence intervals.
construction of bootstrap confidence intervals, different types of confidence intervals

Block bootstrap methods for nonstationary time series.
Moving Block Bootstrap, Nonoverlapping Block Bootstrap, Circular Block Bootstrap, Stationary Bootstrap, consistency results for basic characteristics of stationary time series

Block length choice.
asymptotic efficiency, comparison of asymptotic variances for different block bootstrap methods, adaptive methods of block length choice

Block bootstrap methods for cyclostationary and almost cyclostationary time series.
Generalized Seasonal Block Bootstrap, Extension of the Moving Block Bootstrap, consistency results for basic characteristics

Bootstrap for ARMA models
basic bootstrap algorithms, discussion of possible generalizations into periodic series

Bootstrap in the frequency domain.
Frequency Domain Bootstrap, bootstrap algorithm for spectral density, consistency results

Subsampling method.
subsampling method, consistency results for stationary time series, subsampling consistency results for different characteristics of periodic and almost periodic processes

Subsampling - methods of subsample length choice.
Minimum Volatility Method, method based on logarithm of quantile

A new method for estimating spectral density of nonstationary series.
Method for the spectral density estimation of almost cyclostationary time series with non-zero mean function

Laboratory classes

Analisis of stationary sequences.
Fitting ARMA series to real data, removing of trend and seasonality, ACF and PACF functions

Spectral analysis of stationary time series.
Generation of various types of stationary series, estimation of their spectral density functions, discussion of the leakage effect

Cyclostationary processes
Generation of various types of processes that are periodically correlated, estimation of their characteristics

PARMA series
Fitting the PARMA model to the real data: identification, estimation, forecast

Generalizations of cyclostationary series.
Generation of various types of processes that are almost periodically correlated, estimation their characteristics

IID bootstrap. Bootstrap confidence intervals.
Coding of IID bootstrap, analysis of bootstrap statistics distribution. Construction of different types of confidence intervals for various of parameters, discussion and

interpretation of results

Block bootstrap methods for stationary time series.
Coding algorithms of block bootstrap methods for stationary series. Estimation of mean, construction of confidence intervals

Methods for block length choice.
Comparison of performance of different block bootstrap algorithms for various types of block lengths, calculation of actual coverage probabilities

Bootstrapping ARMA models
Construction of bootstrap parameter estimators of the ARMA model

Block bootstrap methods for cyclostationary and almost cyclostationary time series.
Coding algorithms of block bootstrap methods for cyclostationary and almost cyclostationary series. Estimation of characteristics in time and frequency domain, construction of confidence intervals

Bootstrap in the frequency domain.
Frequency Domain Bootstrap algorithm, application for real data

Subsampling.
The use of subsampling algorithm to estimate the overall mean of stationary series, comparison of results with block bootstrap methods

Subsampling for nonstationary data.
Use of subsampling algorithm for estimation of characteristics of cyclostationary series, comparison of results with block bootstrap methods

Subsampling - methods of subsample length choice.
Finding optimal block lengths using various adaptive methods

Presentations of projects
Defense of projects

Teaching methods and techniques:

Lectures: Nie określono
Laboratory classes: Nie określono

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

The condition of admission to the exam is having the positive grade from laboratory classes. If the student did not pass the laboratory classes, the student has the second opportunity to defend the project. The grade from laboratory classes is calculated on the basis of activity during course and grade from the project. Two unjustified absences during laboratory classes are possible.
The oral exam covers the issues presented in the lecture.

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Presence is not obligatory.
Laboratory classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Presence is obligatory, 2 unjustified absences allowed.

Method of calculating the final grade
The final grade is calculated as a weighted average of the exam and laboratory grades. The grade from laboratory exercises depends on the preparation and presentation of the solution to the problem. The weight of the evaluation of the laboratory = 0.5. The weight of the oral exam grade = 0.5.

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:
In the case of absence the students are obligated to prepare the material for the next classes on their own.

Prerequisites and additional requirements
Basic knowledge of statistics and programming.

Recommended literature and teaching resources
Brockwell P.J. and Davis, R.A. (1991) Time Series Theory and Methods. 2nd Edition, Springer-Verlag, New York.

Hurd, H.L., Miamee, A.G. (2007). Periodically Correlated Random Sequences: Spectral. Theory and Practice. Wiley.

Lahiri, S.N. (2003) Resampling Methods for Dependent Data, Springer, New York.

Napolitano, A. (2012). Generalizations of Cyclostationary Signal Processing: Spectral Analysis and applications. Wiley-IEEE Press.

Scientific publications of module course instructors related to the topic of the module
A.E. Dudek, J. Le±kow, E. Paparoditis and D. Politis (2014). A generalized block bootstrap for seasonal time series, J. Time Ser. Anal., 35, 89-114.

D. Dehay, A. Dudek and J. Le±kow (2014). Subsampling for continuous time nonstationary stochastic processes, J. Stat. Plan. Inf., 150, 142-158.

A.E. Dudek, M. Maiz and M. Elbadaoui (2014). Generalized Seasonal Block Bootstrap in frequency analysis of cyclostationary signals, Signal Process., 104C, 358-368.

A.E. Dudek (2015). Circular block bootstrap for coefficients of autocovariance function of almost periodically correlated time series, Metrika, 78(3), 313-335

A.E. Dudek, E. Paparoditis and D. Politis (2016). Generalized Seasonal Tapered Block Bootstrap, Statistics and Probability Letters, 115, 27-35.

A.E. Dudek, H. Hurd and W. Wójtowicz (2016). Periodic autoregressive moving average methods based on Fourier representation of periodic coefficients, Wiley Interdisciplinary Reviews: Computational Statistics,
8(3), 130-149.

A.E. Dudek (2018). Block bootstrap for periodic characteristics of periodically correlated time series. Journal of Nonparametric Statistics, 30(1), 87-124.

D. Dehay, A.E. Dudek and M. Elbadaoui (2018). Bootstrap for almost cyclostationary processes with jitter effect, Digital Signal Processing, 73, 93-105.

Additional information
None