TELE7374 Special Topics in the Internet of Things: Machine Learning Algorithms for IoT Systems

COURSE INFORMATION

Course Title**:** Special Topics in the Internet of Things: Machine Learning Algorithms for IoT Systems
Course Number: TELE 7374
Term and Year: Spring 2024
Credit Hour: 4
Course Format: In-person

INSTRUCTOR INFORMATION

Name: Abhishek Murthy (https://www.linkedin.com/in/abhishekmurthy)
E-mail Address: a.murthy@northeastern.edu

COURSE PREREQUISITES

None

COURSE DESCRIPTION

This course provides skills necessary to design, develop, roll-out and maintain machine learning algorithms for IoT Systems that generate time series data. Consequently, it will help the students specialize in verticals like Industry 4.0, Wearables, Health, Smart grids/homes, etc.

Students will go beyond traditional machine learning courses and learn the nuances of handling time series data from IoT systems and maximize their impact as data scientists. The course will entail specializing in data preparation and exploration of sensor data. Customized performance metrics for time series machine learning algorithms will be covered. Domain-specific problem classes, like forecasting, change point detection and temporal anomaly detection will be covered in detail. Deep learning architectures specific to time series problems will be explained. The course projects will focus on time series, thereby going beyond the traditional tabular/ image datasets used in fundamental machine learning classes.

The course has a laboratory component. In addition to the conceptual problems, each student must perform several laboratory assignments on his/her computer in a sandboxed virtual machine. Labs include fundamentals of *exploratory data analysis and problem framing, time series anomaly detection and changepoint detection, regression, forecasting and classification*. The primary focus of the assignments will be on cloud-based implementations of the respective algorithms. Opportunities will also be provided to explore *embedded and edge implementations*.

The course culminates in a project where the students apply the acquired conceptual and practical knowledge of time series machine learning to build an end-to-end machine learning system . The project can be done in teams.

COURSE LEARNING OUTCOMES

Upon successful completion of this course, students will be able to:

- Broad understanding of the IoT Analytics industry, pain points and business models
- Usecases in the industry (Predictive Maintenance), Energy (energy management), Healthcare (wearable data analytics)
- Univariate and multivariate time series, understanding relationships between variables
- Signal processing
- Time series data exploratory data analysis (EDA)
- Window Size Selection (WSS)
- Types of anomalies: univariate and multivariate data
- Z-Scores, Inductive Monitoring System, k-NN, k-PCA
- Change point detection
- Matrix Profile techniques
- ARIMA
- Regression trees
- Hierarchical/ Grouped Forecasting
- Time and date-based features
- Feature engineering: TSFresh, ROCKET, shapelets
- HIVE-COTE
- XGBoost for Time Series
- Autoencoders
- 1D Convolutional Neural Networks
- LSTM networks
- Deep learning architectures for forecasting
- Edge and embedded AI
- Predictive maintenance: Health indices, fault diagnostics and Remaining Useful Lifetime prediction
- Wearables: Human Activity Recognition
- Energy: forecasting at different scales

RECOMMENDED REFERENCES

Machine Learning for Time-Series with Python: Forecast, predict, and detect anomalies with state-of-the-art machine learning methods
Ben Auffarth
ISBN-13: 978-1801819626

COURSE WEBSITE

TBA

TENTATIVE SCHEDULE

WEEK	*TOPIC*	*TYPE*
1	*Introduction to Time Series Machine Learning for IoT*	*Lecture*
2	*Exploratory Data Analysis for Time Series Data*	*Lecture*
3	*Time Series Anomaly Detection (TSAD)*	*Lecture*
4	*Change Point Detection*	*Lecture*
5	*Time Series Regression*	*Lecture*
6	*Time Series Modeling & Forecasting*	*Lecture*
7	*Time Series Modeling & Forecasting (Hierarchical/grouped models)*	*Lecture*
8	*Midterm | Guest Lecture (Special topics)*	*Exam | Lecture*
9	*Time Series Classification (TSC)*	*Lecture*
10	*Time Series Classification (TSC)*	*Lecture*
11	*Deep Learning Architectures for TSAD and Modeling*	*Lecture*
12	*Deep Learning Architectures for TSC*	*Lecture*
13	*Applications: Industry 4.0, Energy Management, Health*	*Lecture*
14	*Project Presentations*	*Project*
15	*Final*	*Exam*

INSTRUCTION METHODOLOGY

This course will combine traditional lectures with hands-on assignments that reinforce the lecture material. In particular, classes will focus on concepts and ideas, while the assignments will provide substantial experience and skills. Students will also have a final project, allowing them to apply the learnings from the lectures to interesting topics.

GRADING POLICY

Coursework will be weighted as follows:

Assignments	30%
Quizzes	5%
Project	30%
Midterm	15%
Final Exam	20%

MAKEUP POLICY
All assignments and labs are due by the respective deadlines. A student can delay one of their submissions by at most 1 week. Prior notice must be given before availing this request.

EXAMINATION POLICY
There are two primary examinations: the mid-term and the final exam. The dates/rooms for these examinations will be announced beforehand. The examinations will consist of material that has been covered, and a review will occur the week before each examination.

GRADING SYSTEM

Grade	Weight	Numerical Definition	Definition
A **A-**	4.000 3.667	93 – 100 90 – 92	Student learning and accomplishment far exceed published objectives for the course/test/assignment, and student work is distinguished consistently by its high level of competency and/or innovation.
B+ **B** **B-**	3.333 3.000 2.667	87 – 89 83 – 86 80 – 82	Student learning and accomplishment meet all published objectives for the course/test/assignment, and student work demonstrates the expected level of understanding and application of concepts introduced.
C+ **C** **C-**	2.333 2.000 1.667	77 – 79 73 – 76 70 – 72	Student learning and accomplishment based on the published course/test/assignment objectives were met with minimum passing achievement.
F	0.000	0 – 69	Student learning and accomplishment based on the published course/test/assignment objectives were not sufficiently addressed or met.

https://registrar.northeastern.edu/article/university-grading-system/

ATTENDANCE POLICY
Attendance is a crucial element for success in class. Unless you cannot make it due to illness or other urgent or emergent reasons, it is required. Contact me via e-mail before class for allowed absence unless you cannot. Here is the section from the student handbook: Students will not be penalized for excused absences, with the understanding that students may need to make up for the academic commitment from which they were excused. Reasons for an excused absence include religious, medical issues, jury duty, bereavement, and military service. See the course catalog and other applicable policies for attendance and excusal guidelines.

ACADEMIC INTEGRITY
A commitment to the principles of academic integrity is essential to the mission of Northeastern University. Promoting independent and original scholarship ensures that students derive the most from

their educational experience and pursuit of knowledge. Academic dishonesty violates the most fundamental values of an intellectual community and undermines the achievements of the entire University.

As academic community members, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, examinations of whatever kind, collaborative work, using study aids, the appropriateness of assistance, and other issues. Students are responsible for learning documentation conventions and acknowledging sources in their fields. Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments according to the highest ethical standards, as set forth either explicitly or implicitly in this Code or by the direction of instructors. Go to http://www.northeastern.edu/osccr/academic-integritypolicy/ to access the full academic integrity policy.

UNIVERSITY HEALTH AND COUNSELING

As a student enrolled in this course, you are fully responsible for assignments, work, and course materials outlined in this syllabus and the classroom. Over the semester, if you experience any health issues, please contact UHCS. For more information, visit https://www.northeastern.edu/uhcs.

STUDENT ACCOMMODATIONS

Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the university's activities. To receive accommodations through the DRC, students must provide appropriate documentation demonstrating a substantially limiting disability. For more information, visit http://www.northeastern.edu/drc/getting-started-with-the-drc/.

LIBRARY SERVICES

The Northeastern University Library is the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals. For more information and for education-specific resources, visit https://library.northeastern.edu.

24/7 CANVAS TECHNICAL HELP

For immediate technical support for Canvas, call 617-373-4357 or e-mail help@northeastern.edu
Canvas Faculty Resources: https://canvas.northeastern.edu/faculty-resources/
Canvas Student Resources: https://canvas.northeastern.edu/student-resources/
For assistance with my Northeastern e-mail and essential technical support:
Visit ITS at https://its.northeastern.edu
E-mail: help@northeastern.edu
ITS Customer Service Desk: 617-373-4357

DIVERSITY AND INCLUSION

Northeastern University is committed to equal opportunity, affirmative action, diversity, and social justice while building a climate of inclusion on and beyond campus. In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration, and an awareness of global perspectives on social justice. I intend that students from all backgrounds and perspectives will be well served by this course and that the diversity students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic backgrounds, family education levels, ability – and other visible and non-visible differences. All class members are expected to contribute to a respectful, welcoming, and inclusive environment for every other class member. Your suggestions are encouraged and appreciated. Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion.

TITLE IX

Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender identity, in educational programs and activities that receive federal financial assistance. Northeastern's Title IX Policy prohibits Prohibited Offenses, defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty, and staff. In case of an emergency, please call 911. Please visit https://www.northeastern.edu/ouec for a complete list of reporting options and resources on and off campus.

This course syllabus may be subject to change.