Time Series Analysis - ISYE 6402

Spring 2027
Instructor: Dr. Nicoleta Serban

Course description:

An introduction to commonly used time series analysis models and novel forecasting systems, along with implementation of the models within data examples using the R statistical software and python software.

Course prerequisites:

A sound knowledge about undergraduate or graduate statistics, and regression analysis but also basic programming proficiency, linear algebra and basic calculus.

Required course materials

The required course materials include the course slides and videos along with data analysis examples and codes provided in the GitHub repository developed for this course.

Attendance policy

Attendance is measured by your ongoing participation in class discussion and course activities. Students should engage with course materials each week, complete assignments by the posted deadlines, participate in class discussions and participate in piazza discussions and other course components such as peer assessments as assigned.

Course objectives: What knowledge and skills will learners gain from this course?

In this course, learners will learn standard time series analysis topics such as modeling time series using regression analysis, univariate ARMA/ARIMA modelling, (G)ARCH modeling, Vector Autoregressive model along with forecasting, model identification and diagnostics. Building on these fundamental time series modeling concepts, the last module of the course will also present the methodology and implementation of well-established machine learning (ML) forecasting systems including Meta's Prophet , LinkedIn's Silverkite and Uber's Orbit complemented by a brief introduction on other ML and Deep Learning approaches inspired by commonly used tools such as neural networks. The course material will be accompanied by a GitHub repository including all data examples and implementations used to illustrate the fundamentals of time series learned in the course.

Learners will be given fundamental grounding in the use of some widely used tools, but much of the energy of the course is focused on individual investigation and learning. Active participation in the class is very important. This class is more about the opportunity for individual discovery than it is about mastering a fixed set of techniques. By the end of this class, it is expected that you will have the skills to answer time series data analysis questions, select appropriate time series tools to address the questions, know how to perform the implementation and interpret the results with the context of the data analysis scope. While the course might feel heavy in statistical learning, the purpose is to support your understanding of the fundamentals of time series modeling. There are many time series models and forecasting approaches developed that use the concepts of the modeling techniques in this course. Your understanding of the fundamentals of time series modeling will be useful in the understanding and the applicability of such models as well as other machine learning approaches. While you might be able to apply such tools blindly

without knowing the fundamentals, you will not know why/whether the results are good or bad, why/when to use one approach over another, how to compare models, how can improve on your analysis etc. Learning the fundamentals might be hard but it will give you an advantage in performing a time series analysis more rigorously than a GenAI tool!

What activities will the course involve learners in to help them practice and demonstrate their learning?

- **Homework Assignments**

There will be five assignments, primarily focusing on data analysis using the R statistical software or python software. The homework assignments will also include additional questions that are evaluating learners' understanding of the methodological course material, solidifying the foundation for implementation of the time series concepts. These assignments are intended to help you better understand the course material and to prepare for the midterm exams and the class project.

Note: The implementation of the module introducing ML forecasting approaches (Module 5) is primarily implemented in python; the R statistical software does not have the appropriate libraries and packages for the implementation of data analysis for this module. Thus, it is advisable to develop your understanding of both software packages using the homework assignments.

- **Midterm Exams:**

There will be two midterm exams with problems reviewing the material (lectures and assignments) provided in this course. The exams are designed to help learners grasp standard time series analysis methodology, which will further facilitate a deeper understanding in the application context. The exams are open-book since they mainly focus on data analysis although some methodological questions will be included also. Please read carefully the Open-Book Policy below.

➔ What we mean by open-book is that learners are allowed to refer to course class material, including lectures and homework assignments, any material provided in the course. Open-book includes any notes you may have stored on your computer on the course topics; make sure you store the course material on your computers not online systems, e.g. google colab. Only one computer (screen) is allowed during exams. Open-book in this course does **NOT** include access to the internet, or communication by any means. The policy will allow use of Stack Overflow, R help menu and python doc help menu as the only online site you will be allowed to visit during the exam to get help with coding issues if you get stuck. It does **NOT allow use of Generative AI tools or other web external resources**. Use of the internet and/or communication with anyone during the exam will be subject to the Georgia Tech honor code and conduct policies/actions (https://www.policylibrary.gatech.edu/learner-life).

Please note that taking the exam in canvas using the Honorlock proctoring application limits learners' use of various platforms. For example, it does not support the use of IDEs such as RTVS, Emacs with ESS, Eclipse with StatET, Sublime Text, Visual Studio, among others File formats such as QMD are also not supported. The use of virtual machines is not supported. Make sure to set up the exam in an environment that follows the exam guidelines, and it is supported within the context of the examination system.

- **Course Project:**
  The general goal of the course project is to provide you with experience in applying time series analysis methodology to real data. For this project, your team will select one of the topics provided for the final project and write a progress and a final report on the analysis of the selected topic. This project will serve as a means for learners to demonstrate what they understand and can do with the course material, but it is also recommended to go beyond that. The course material provides fundamentals of time series analysis, however there is much more that you could build on these fundamentals. In grading, we will primarily look for a sensible approach to the problem, and clearly-made connections between your analyses and the substantive questions to be addressed within the project topic. You can use any computing equipment and any computing resources in the school, any written source material you can find, in or out of the school. However, replicating results which have been already published without referencing to the source of publication is subject to plagiarism. Plagiarizing is defined by Webster's as "to steal and pass off (the ideas or words of another) as one's own: use (another's production) without crediting the source." Be sure to document carefully your project work and cite any external materials you may use.

Additional criteria for successful completion of the course

In addition to meeting all assignments, exams, and project requirements, successful completion of this course requires consistent engagement with the learning process. Students are expected to:

- **Keep pace with weekly course modules** by reviewing lectures, slides, examples, and code demonstrations within the recommended schedule.
- **Regularly monitor Piazza** for pinned announcements, clarifications, and updates, as students are responsible for all content communicated by the instructional team.
- **Participate constructively in Piazza discussions** by asking questions, responding to peers when appropriate, and contributing to a collaborative learning environment.
- **Adhere to all Honor Code expectations**, including submitting original work, properly citing any external resources used, and complying with the course's policies regarding Generative AI tools.
- **Prepare appropriately for exams and the final project**, including maintaining an organized local copy of allowed course materials and ensuring technological readiness for proctored assessments.
- **Demonstrate professional conduct and netiquette** in all course-related communications.

Meeting these expectations is essential to supporting your own learning, contributing to the online learning community, and achieving the intended outcomes of the course.

Grading Policy:

The course will be letter graded. The grade for the course will be based on the two midterm exams, a course project, and assignments during the semester - ***Midterm 1: 20%, Midterm 2: 25%, Final Project: 35%, Assignments: 20%.***

The final course grade will be converted into letter grades as follows:
A – 90 to 100
B – 80 to 89
C – 66 to 79
D – 50 to 65
F – below 50

Academic Integrity & Acceptable Student Conduct Statement

All course participants (instructor, teaching assistants, staff and learners) are expected and required to abide by the policies of the Georgia Tech Academic Honor Code, and the Student Conduct expectations (http://www.policylibrary.gatech.edu/student- life). Keep in mind:

- Ethical behavior and personal integrity are extremely important in all facets of life.
- Learners are responsible for completing their own original work. If external resources outside of the course material (including solutions to prior homework assignments) or collaboration with other learners are to be used in homework assignments, they need to be referenced properly. Generative AI tools must not be used to generate responses to homework questions (see Use of Generative AI Tools below); any other use of such tools needs to be referenced properly**. Lack of reference is a violation of the honor code.**
- Use of Generative AI tools and any other internet resources will NOT be allowed during the exam, when students will need to demonstrate their learning without relying on external resources. **Use of such resources is a violation of the honor code. Read also the open book policy.**
- Internet resources may be used as collaborative tools for the course project. Generative AI tools may be used only as described in the Use of Generative AI Tools section below (e.g., to clarify concepts or support coding), and not for the data analysis or the writing of the report. Project work must be learners' own work. You should not include anything that was not written directly by you without citation. **Lack of reference and citation of the resources used is considered as academic misconduct thus a violation of the honor code.**

Any course participant found in violation of the Georgia Tech Academic Honor Code and/or the Georgia Tech Student Conduct expectations will be subject to the following consequences: 1. Institute a disciplinary warning and assign a grade of zero for the assignment or exam; and 2. Forward the resolution to Georgia Tech's Office of Student Integrity.

Use of Generative AI Tools:

Generative AI tools are now becoming a more integrative part of how we derive knowledge. However, they are a two-edged sword. While they provide opportunities for learning, they also hamper self-learning in a way that new knowledge might not be solidified for understanding new concepts and replicating rigorous analyses. Such tools may also interfere with the development of accurate knowledge since when such tools don't know the answer will make up an answer! Also relying on such tools for learning will particularly impact the employment of your skill set to derive knowledge – it raises the bar of knowledge as highlighted by the Professor Chris Dede. See the link below for more information:
https://www.gse.harvard.edu/ideas/edcast/23/02/educating-world-artificial-intelligence

In this course, we will treat the Generative AI tools similar as collaboration with other people: you are welcome to talk about your work with other peer learners as well as with AI-based assistants. However, **all work you submit must be your own**. You should never include in your assignment anything that was not written directly by you without proper reference.

Using Generative AI tools could be useful in this course as follows:

- Inquiries about (basic) concepts in the course to complement the explanation of these concepts in the course material. You will have to thread this carefully since the information provided by such tools may not be accurate/correct/rigorous. Do not use these tools as your only approach to complement learning.
- Inquiries about the use of R and python commands that could help in speeding up the process of learning data analysis implementations. The course material provides the coding needed to understand the course material, but such tools may provide additional support that could improve your use of the course material, for example, better ways to develop visual analytics, or use of python commands that could translate the R code provided in the course.

It is unavoidable that such tools will be part of the learners' learning hence it is expected that you will

consult Generative AI in some instances that could enhance your learning. It is however **the learners' responsibility** to assume that the information from AI tools will not always be accurate thus you will need to check with your instructor team and/or other resources.
Learners need to be aware of the potential harm to their learning as follows:

- Inquiries on developing R or python code for data analyses or on providing interpretations of the data analysis could result in code commands or interpretations that are superfluous, and don't necessarily give a rigorous answer to the problem at hand. Such inquiries will not help learners understand what each command is meant to do thus not being able to replicate rigorous data analyses on their own. It is thus important **NOT** to use Generative AI tools to respond to the homework assignment or exam questions. Submitting the assignment and exam questions to such tools is also not compliant with Georgia Tech policies on sharing the course material beyond the classroom learning. *Thus, we will consider an honor code violation if the responses to assignment and exam questions are generated by such tools.*
- Inquiries on writing up your report will NOT be allowed. Your report writing needs to be your team's work alone. It is important to develop your own writing skills and be able to write about your data analysis in your own words. *Thus, we will consider an honor code violation if your report uses Generative AI tools to be developed and written.*
- Inquiries on any aspect related to learners or instructors, and other individual-level information are considered violations of the Georgia Tech Guidelines on Generative AI for Privacy and Security. Please read carefully the Georgia Tech Guidelines: https://gatech.service-now.com/home?id=kb_article_view&sysparm_article=KB0043472

While we understand that Generative AI tools may be used to complement learning and to enhance coding skills, learners should NOT use such tools for developing solutions to homework assignments or exams or the report analysis and write up. Please read about some heuristics and recommendations at: https://www.cc.gatech.edu/news/new-policies-navigate-role-ai-assistants-cs-courses.

Communication:

Course updates will be sent through the piazza platform on Canvas. Please contact your instructor, teaching assistants, and fellow learners via piazza.

- The course will host a class discussion forum using piazza. Feel free to ask questions and respond to other learners' questions to the best of your knowledge; this is a learning community, supporting each other.
- While participation in the discussion forum is not mandatory, students are responsible for knowing the content of all pinned Piazza posts. This is where the instructor team will be letting learners know about important announcements, changes (if any), etc., thus all learners are required to read and know the content of all such posts. It is expected that learners will check these posts at least once every 24 hours (with exceptions for national and religious holidays, emergencies, etc.).
- Communicate with instructors, teaching assistants and fellow learners using your name as listed in the learner roster. E-communication can be less constructive or less thoughtful than in-person communication. When someone does not introduce himself or herself, it is easier to be less respectful. To avoid sensitive situations, we are asking everyone to post in piazza with their name. **Posts made by Anonymous profiles will not be responded to.**
- Please search piazza for your question prior to posting a new one as it may already be answered.
- Instructors and teaching assistants may not be able to address all piazza communications, so we encourage fellow learners to respond to posts. If there is a delay in the instructor or teaching assistant response, please be patient and know there may not be a response if we are in a week with heavy volume and/or if the question has already been addressed in a different post.
- Overall, the discussions will be supervised and monitored by teaching assistants under instructor's guidance.

Netiquette:

Netiquette refers to etiquette that is used when communicating on the Internet. Review the Core Rules of Netiquette.

- When you are communicating via email, discussion forums or synchronously (real-time), please use correct spelling, punctuation and grammar consistent with the academic environment and scholarship.
- *In Georgia Tech's MS in Analytics program, we expect all participants (learners, faculty, teaching assistants, staff) to interact respectfully. Learners who do not adhere to these expectations may be removed from the course.*

Course Topics and Schedule:

Please see accompanying documents on Course Outline and Course Schedule.

Course Technology/Software Requirements:

- Internet connection (DSL, LAN, or cable connection desirable)
- R statistical software (free download; see cran.r-project.org)
- Python software (free download; see https://www.python.org/downloads/)
- Adobe Acrobat PDF reader (free download; see https://get.adobe.com/reader/)
- Jupyter Notebook (free download; see https://jupyter.org/)

University Policy for Students with Disabilities

Georgia Tech welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office of Disability Services. For further information regarding ODS, please visit the Office for Disability Services Web site at http://disabilityservices.gatech.edu.To receive consideration for course accommodations, you must contact ODS and provide documentation, such as academic adjustment letters, at the beginning of each semester.