GIS 4123C: GeoAI – Geographic Artificial Intelligence (3 Credit Hours)

Dr. David Keellings
T 10:40-12:35 R 11:45-12:35 3006 Turlington Hall Spring 2023

Office Hours
Wednesday 10:00 pm - 12:00 pm, other times **BY APPOINTMENT ONLY**
Office: 3117 Turlington Hall
Email: djkeellings@ufl.edu
Note: For best results – utilize office hours. If you are having trouble with the course, come and see me sooner rather than later so that I can help you.

Course Description
Students will learn fundamental concepts and widely used methodologies for GeoAI. The Integration of Geography and AI, or GeoAI (a subfield of spatial data science), provides novel approaches for addressing a variety of geospatial problems in the natural environment and our human society. All labs will be hands-on using real-world geospatial data to address such AI topics as linear models, tree-based methods, spatial cross validation, super learning, deep learning, and interpretable AI. Students will benefit from assignments exploring a mixture of physical and social datasets as well as utilizing UF's supercomputer HiPerGator for analysis tasks. This course will integrate perspectives from the physical and social sciences to identify and describe what geographic artificial intelligence is, what kind of questions we can answer using these tools and how we can apply them to real world data.

Student Learning Objectives
The primary objective of this course is to develop student knowledge and understanding of the principles, techniques, and applications of Geographic Artificial Intelligence. Assigned exercises promote a 'hands-on' approach for understanding, as well as a challenging avenue for exploration and creativity. Specifically, the course objectives are for the student to be able to:

- Describe the historical perspective of GeoAI and its foundations
- Explain the relations between AI, machine learning and deep learning
- Develop expertise in the most-widely used GeoAI and ML tools and technologies
- Apply GeoAI techniques to different geographical questions and geospatial datasets
- Facilitate discussion on why geography and GIS are critical for AI to address many of the real-world problems
- Design and lead a presentation on the current state-of-the art in GeoAI and the current limitations
- Demonstrate effective oral communication of a real-world example of a GeoAI application

NOTE: This course is co-listed with GEO 6938 which is an undergraduate course. While the two will meet together and complete similar assignments and exams, undergraduates and graduates will be evaluated on a different basis. Graduate students are also required to propose and execute a more rigorous independent data analysis project, complete a longer project report, and present their project to the class.

Course Resources

There is no required text for this course. However, you might find the following resources useful:

- Gareth, James, Witten Daniela, Hastie Trevor, and Tibshirani Robert. An introduction to statistical learning: with applications in R. Spinger, 2013. https://www.statlearning.com/
- Robin Lovelace, Jakub Nowosad, Jannes Muenchow, 2020. Geocomputation with R, 1st edition. CRC Press. https://geocompr.robinlovelace.net/index.html
- Boehmke, Brad, and Brandon Greenwell. Hands-on machine learning with R. Chapman and Hall/CRC, 2019. https://bradleyboehmke.github.io/HOML/
- An Introduction to R manual is freely available here: https://cran.r-project.org/manuals.html

Furthermore, throughout the semester readings will be distributed and discussed. All of these readings will be free, online books or articles and will be posted on the class website.

Computer/Software Requirements

- R (http://cran.us.r-project.org) is a free command-line based statistical language.
- RStudio is a free IDE for R (http://www.rstudio.com/)

We will install these programs together at the first lab meeting. All of these programs are free and multi-platform compatible (Windows, Mac, Linux). Install R first and then RStudio. Use the latest versions of each.

This course will be held in TUR 3006, which is a flipped classroom with both desks and discussion area and computer terminals. Students do not need to provide their own laptop computer as they will have full access to the geography computer lab for this course. Lab access will also be available outside class times and in evenings and weekends.

Grades and Grading Scale

Labs (8 labs, lowest grade dropped): 40% (8 labs @ 5% each)
Class Discussion: 5%
Exams (2 @ 15%): 30%
Project Proposal: 5%
Project Presentation: 10%
Project Report: 10%

- **Labs:** Learning these techniques is challenging and weekly labs are reserved for in-class work and one-on-one instruction. For this reason, attendance in weekly labs is required. Labs missed without permission from the instructor will result in a zero for that week's lab assignment. Lab assignments are due by the end of the next lab period (one week after initial assignment). Late assignments will have 10 percent deducted from the possible total score for each day they are late (E.g. if you earn an 80% on the lab but are one day late you receive a 70%). The lowest lab grade will be dropped.

- **Class Discussion:** Each week a small group of students will present a summary of that week's reading assignment. The presentation should consist of a concise summary of the article and lead into discussion questions for class participation. A sign-up sheet will be posted on the class website for you to pick a topic/week of presentation. Group sizes will be limited, and topic/date is chosen first-come-first-served. Each group member will be expected to contribute to the presentation and discussion points. Each group member will be evaluated based on presentation/discussion performance and within group peer-evaluation. See reading sign-up sheet and presentation grade rubric.

- **Exams:** Exams will be used to evaluate your proficiency in the course material. Two exams will be given that cover only the material since the previous exam.

- **Project:** Working individually you will propose and execute an analysis of data using techniques learned in the class. You will be graded on the viability of your proposal i.e., is the proposed study suitable for an AI workload and can the work be reasonably completed during the course of a single semester. You will present your project to the class at the end of the semester and also hand in a project report written in the form of a short paper not to exceed 5 pages, excluding references.

>=91.0% = A	90.0-90.9%= A-	87.0-89.9%= B+	81.0-86.9%= B
80.0-80.9%= B-	77.0-79.9%= C+	71.0-76.9%= C	70.0-70.9%= C-
67.0-69.9% = D+	64.0-66.9%= D	60.0-63.9%= D-	<60.0% = E

A grade threshold must be crossed in order to receive the letter grade indicated (no rounding). It is your responsibility to know your current grade. Grades will be posted to the course website. Information on current UF grading policies for assigning grade points may be found at https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx.

Make-Up Assignments
Students must notify the instructor as soon as possible in case of absence and provide documentation as to the reason for the absence. If deemed an excused absence, the student will be permitted one week from their return to classes in order to make up the missed work with no grade penalty. Requirements for make-up assignments and other work in this course are consistent with university policies that can be found at https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

Late Work
Late assignments will have 10 percent deducted from the possible total score for each day they are late (E.g. if you earn an 80% on the work but are one day late you receive a 70%).

Canvas Course Website Information
This syllabus, announcements concerning assignments, lecture content (including code and data), grades, and other course information will be posted on Canvas course management system. Access this page at https://elearning.ufl.edu/. If you miss a class, it is your responsibility to learn the material covered during your absence. Come see me if you have any questions. Students must activate their UF GatorLink account in order to use Canvas. If you need help learning how to perform various tasks related to this course or other courses that utilize Canvas, please consult the above webpage. You may also contact the UF Computing Help Desk at (352) 392- HELP(4357) or helpdesk@ufl.edu

Accommodations for Students with Disabilities
Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester. After initial arrangements are made with that office, notify me in writing as soon as possible, and a minimum of one week before an exam.

Academic Honesty
UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code.” On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor code (http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors

that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor.

Attendance and Proper Conduct

I have no policy of mandatory attendance. You are all adults and can decide to come to class or not. But you are also the only person responsible for attaining the grade you want. When you enter the lecture room you are doing so of your own will, not because you are being forced to. When you make the choice you are also agreeing to show respect to your fellow students by allowing them to hear the lecture materials without having to compete with background chit-chat. Turn off cell phones, put away newspapers, and refrain from casual conversation once class begins. If you have a question – please raise your hand or ask at the end of class.

Recordings and Notes: It is not permitted to sell or distribute notes or recordings from this class without written consent of the instructor. Nor are students permitted to disseminate recordings of the instructor lecturing or post copies of assignments or exams on the internet.

The University of Florida is committed to an ethical, inclusive community defined by respect and civility. The University of Florida prohibits discrimination against any person. The UMatter website (https://umatter.ufl.edu/refer-or-report/) provides a list of reporting channels that can be used to report incidences of illegal discrimination, harassment, sexual assault, sexual violence, retaliation, threat assessment or fraud.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course based on 10 criteria. These evaluations are conducted online at https://evaluations.ufl.edu. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results.

Your evaluations are used by faculty to improve their courses and teaching methods, and by department chairs and college deans to assess teaching effectiveness. Without your responsible input, we cannot effectively assess and improve teaching performance and student learning. Please be honest, fair, and constructive as you complete your evaluations.

Campus Resources

Health and Wellness

- U Matter, We Care: Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.
- Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.
- Sexual Discrimination, Harassment, Assault, or Violence: If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu
- Sexual Assault Recovery Services (SARS)

- Student Health Care Center, 392-1161.
- University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/

Academic Resources

- Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://career.ufl.edu/
- Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.
- Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.
- Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.
- Student Complaints Campus: https://registrar.ufl.edu/complaint.html.
- On-Line Students Complaints: http://www.distance.ufl.edu/student-complaint-process.

Course Schedule (Subject to Change)

Week	Topics	Labs (Tuesday)	Readings (Thursday)
1	Introduction to AI and R	NO LAB	NO READINGS
2	Intro to GeoAI	Lab 1: Multiple Regression with Economic Data	Reading #1: Hu et al Reading #2 GeoAI blog
3	History of AI in Geography	Lab 2: Random Forest for Economic Data	Reading #3: Couclesis Reading #4: Smith
4	The Fourth Paradigm	Lab 3: RF for Vegetation Modeling	Reading #5: Hey et al Reading #6: Vahedi et al
5	Spatially Explicit Models	Lab 4: Generalized Linear Models for Landslide Susceptibility	Reading #7: Goodchild Reading #8. Yan et al
6	Question Answering and Summarization	Lab 5: SVM for Landslide Susceptibility on HiPerGator	Reading #9: Hu Reading #10: Goodchild & Janelle
7	EXAM 1	NO LAB	EXAM 1
8	Social Sensing	Lab 6: Super Learning with Economic Data	Reading #11: Aggarwal & Abdelzaher Reading #12: Liu et al
9	Interpretable AI	Lab 7: Interpretable AI with Economic Data	Reading #13: Toms et al. Reading #14: Dikshit & Pradhan
10	SPRING BREAK	SPRING BREAK	SPRING BREAK
11	INDIVIDUAL WORK	NO LAB – **Proposal Due**	NO READINGS
12	Remotely Sensing Spaces	NO LAB	Reading #15: Yan et al Reading #16: Jacobs et al
13	Deep Learning	Lab 8: Deep Learning for Forecasting ENSO	Reading #17: Guo & Feng Reading #18: Polson & Sokolov
14	INDIVIDUAL WORK	NO LAB	NO READINGS
15	Project Presentations – **Paper Due**	NO LAB	NO READINGS
16	EXAM 2	NO LAB	EXAM 2

Readings

1. Hu, Y., Li, W., Wright, D., Aydin, O., Wilson, D., Maher, O, and Raad, M. (2019). Artificial Intelligence Approaches. The Geographic Information Science & Technology Body of Knowledge (3rd Quarter 2019 Edition), John P. Wilson (ed.). DOI: https://doi.org/10.22224/gistbok/2019.3.4
2. GeoAI blog: https://resources.esri.ca/education-and-research/geoai-series-2-the-birth-andevolution-of-geoai
3. Couclelis, H., 1986. Artificial intelligence in geography: conjectures on the shape of things to come. The Professional Geographer, 380 (1), 1–11. doi:10.1111/j.0033-0124.1986.00001.x [Taylor & Francis Online], [Google Scholar]
4. Smith, T.R., 1984. Artificial intelligence and its applicability to geographical problem solving The Professional Geographer, 360 (2), 147–158. doi:10.1111/j.0033-0124.1984.00147.x [Taylor & Francis Online], [Google Scholar]
5. Hey, A.J., et al., 2009. The fourth paradigm: data-intensive scientific discovery. Vol. 1. WA: Microsoft research Redmond. [Google Scholar]
6. Vahedi, B., Kuhn, W., and Ballatore, A., 2016. Question-based spatial computinga case study. In: Geospatial data in a changing world. Helsinki, Finland: Springer, 37–50. [Crossref], [Google Scholar]
7. Goodchild, M., 2001. Issues in spatially explicit modeling. In: D. C. Parker, T. Berger, and S. M. Manson, eds. Agent-based models of land-use and land-cover change report and review of an international workshop october 47. Irvine, CA, 12–15. [Google Scholar]
8. Yan, B., et al., 2017. From itdl to place2vec: reasoning about place type similarity and relatedness by learning embeddings from augmented spatial contexts. In: Proceedings of the 25th ACM SIGSPATIAL international conference on advances in geographic information systems. Redondo Beach, CA: ACM, 35. [Google Scholar]
9. Hu, Y., 2018. Geo-text data and data-driven geospatial semantics. Geography Compass, 120 (11), e12404. doi:10.1111/gec3.12404 [Crossref], [Google Scholar]
10. Goodchild, M.F. and Janelle, D.G., 2004. Thinking spatially in the social sciences. Spatially Integrated Social Science, 3–17. [Google Scholar]
11. Aggarwal, C.C. and Abdelzaher, T., 2013. Social sensing. In: A. C. Charu, ed. Managing and mining sensor data. Springer, 237–297. [Crossref], [Google Scholar]
12. Liu, Y., et al., 2015. Social sensing: a new approach to understanding our socioeconomic environments. Annals of the Association of American Geographers, 1050 (3), 512–530. doi:10.1080/00045608.2015.1018773 [Taylor & Francis Online], [Google Scholar]
13. Toms, B. A., Barnes, E. A., & Ebert-Uphoff, I. (2020). Physically Interpretable Neural Networks for the Geosciences: Applications to Earth System Variability. *Journal of Advances in Modeling Earth Systems*, *12*(9). https://doi.org/10.1029/2019MS002002
14. Dikshit, A. and Pradhan, B., 2021. Interpretable and explainable AI (XAI) model for spatial drought prediction. *Science of the Total Environment*, *801*, p.149797.
15. Yan, B., et al., 2018. xnet+ sc: classifying places based on images by incorporating spatial contexts. In: S. Winter, A. Griffin and M. Sester, eds. 10th international conference on geographic information science (GIScience 2018). Melbourne, Australia: Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik. [Google Scholar]
16. Jacobs, N., et al., 2009. The global network of outdoor webcams: properties and applications. In: Proceedings of the 17th ACM SIGSPATIAL international conference on advances in geographic information systems. New York, NY: ACM, 111–120. [Google Scholar]
17. Guo, Z. and Feng, -C.-C., 2020. Using multi-scale and hierarchical deep convolutional features for 3D semantic classification of tls point clouds. International Journal of Geographical Information Science, 1–20. [Google Scholar]
18. Polson, N.G. and Sokolov, V.O., 2017. Deep learning for short-term traffic flow prediction. Transportation Research Part C: Emerging Technologies, 79, 1–17. doi:10.1016/j.trc.2017.02.024 [Crossref], [Web of Science ®], [Google Scholar]