Faculty Research

GEOAI for Education

White Paper Author:

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Overview

Geospatial Artificial Intelligence (GeoAI) is the fusion of artificial intelligence with geospatial technology including spatial analysis. The overlap of AI with Geo allows for the opportunity to solve spatial problems as well as identify emerging patterns and trends from data. Most data are inherently spatial, having foundations in both time and space, so GeoAI is particularly relevant to the larger contributions of the use of AI in education and research.

Purpose of the Research

Having used GeoAI techniques in my own research and teaching, I wanted to explore more about the current state of the field to gain further ideas. Using recently published literature, the two questions this white paper seeks to address are: 1) How is GeoAI currently being used? and 2) What are the current challenges of integrating GeoAI into education?

Method

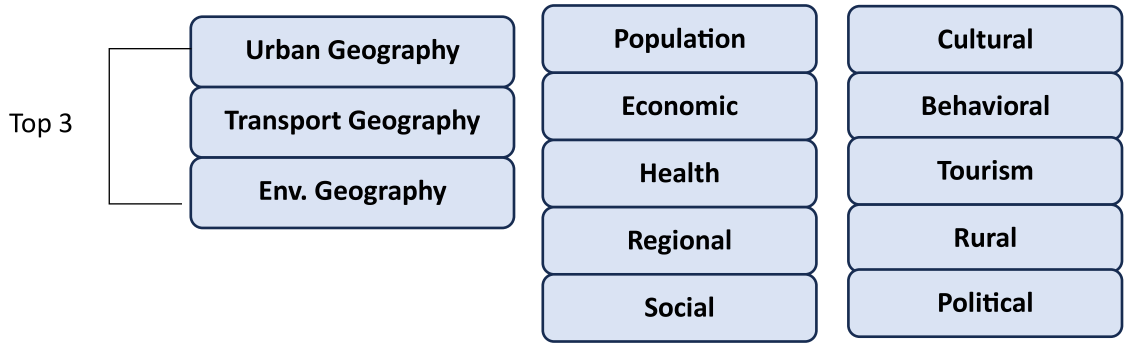
In the review of the literature, I examined a variety of work and the findings of this white paper draw from those. In particular, the work of Wang, et al. (2024) who conducted a PRISMA systematic review of published literature using the Web of Science as their source. Wang, et al. (2024) considered over 1,500 papers that used GeoAI in different subdomains across geography. I chose to follow the same key topic areas identified from the systematic review – highlighting key trends such as subdomains within geography, data types, and modeling tasks that are outlined in greater detail in the Findings and Discussion section of this white paper.

Findings and Discussion

Top.Domains.Using.GeoAI

The top subdomain of Geography that identified the use of GeoAI was urban geography, followed by transport geography and environmental geography. The full list of subdomains identified through the systematic review are shown below in Figure 1.

Figure 1. Top subdomains identified through the systematic review



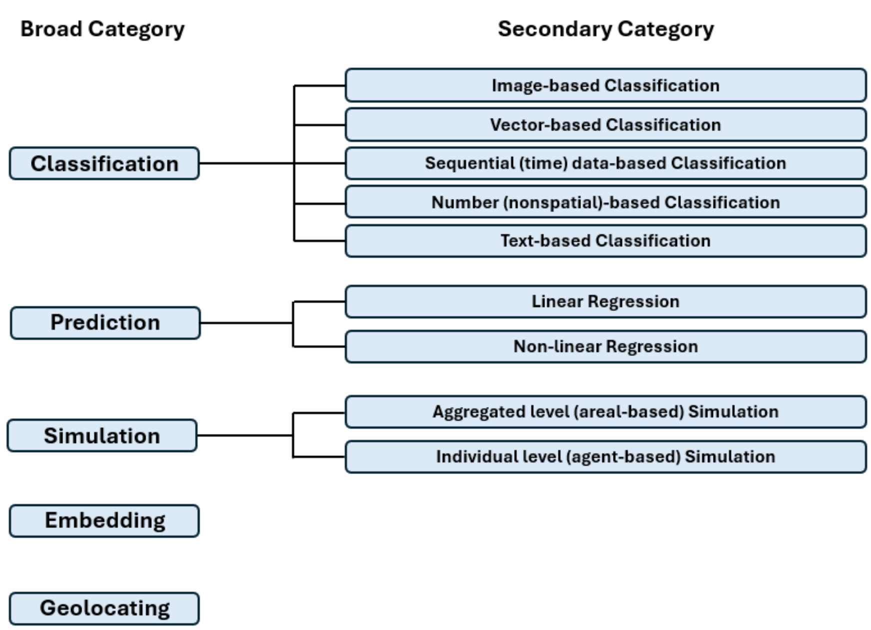
Data Types

The data types identified within the literature varied across the different geography subdomains. Raster and vector formats, the two most commonly used within geospatial mapping and analysis, were the primary data types identified including subtypes that fell within the two categories – such as imagery and geotagged photos as well as GPS locations from mobile devices and data with a time-space component. Additional data types include qualitative and quantitative data such as from surveys or video files.

Modeling Tasks

Modeling Tasks in GeoAI use AI and machine learning techniques to analyze and interpret geospatial data. From the review, three modeling tasks emerged as the top techniques used for analysis. These include prediction methods such as non-linear and linear regression, and image-based classification. Figure 2 shows more information about the full list of modeling tasks identified as well as the more specific types of modeling tasks used.

Figure 2. Modeling tasks identified by broad and secondary categories



Existing Limitations and Challenges

Limitations and challenges exist with the use of any new technology. However, GeoAI has some unique challenges because of its interdisciplinary nature as well as its complex interaction between geospatial concepts and AI algorithms. For the purposes of this white paper, the challenges have been organized around five main themes (Mansourian, A. 2023). This white paper does not seek to answer the existing challenges but rather provide more information to highlight suggested considerations before developing or teaching a course on GeoAI.

- Challenge.7¡.Which.modeling.tasks.should.be.included.in.GeoAI.curriculum?

There is an extensive list of available algorithms and machine learning techniques to use, and the list continues to expand. In a rapidly changing environment, how should educators identify which techniques and algorithms should be included in newly developed GeoAI curriculum? This white paper offers specific modeling tasks that have been identified across 1,000 publications. One opportunity to identify whether the latest technologies are being covered would be to look to recently published literature for what the research field is currently using.

- Challenge.8¡.What.are.baseline.pre_requisites.for.students.entering.a.GeoAI.course?

Before taking a GeoAI course, students should be well versed in geospatial concepts, programming, and data science techniques. Because of the interdisciplinary nature of geospatial technology and AI, students often have varying backgrounds and skillsets. Students from different domains will have specific strengths and familiarity with various techniques and algorithms. Teaching students to navigate and effectively use specific tools and techniques can be challenging, especially for students without prior programming or data science methods experience. Identify resources that exist for students to independently expand on what they are learning.

- Challenge.9¡.How.do.we.balance.the.use.of.traditional.geospatial.techniques.with.GeoAI. techniques?

Traditional AI algorithms seek data independent from one another to identify trends. With geospatial data, the data are often highly heterogeneous and spatial relationships, like spatial autocorrelation (i.e. Tobler's First Law of Geography), can have strong effects on data proximate to one another. Finding and using the strengths of both geospatial technology and AI will help with this challenge. Traditional geospatial techniques may be more suitable for tasks with rule-based spatial relationships (e.g., buffer analysis, spatial joins) while GeoAI would be a better approach for handling large, unstructured data (e.g., satellite imagery classification, spatial-temporal predictions, geotagged data). Another approach would be to begin specific GeoAI tasks by using tried and true methods such as with land use classification – using validated spectral indices such as the Normalized Difference Vegetation Index (NDVI) or the Normalized Difference Built-up Index (NDBI) and then introducing deep learning/machine learning methods to further refine the overall analysis.

- Challenge.0¡.How.do.we.maintain.Active.Learning.Teaching.(ALT).and.evaluate.student.learning?

Active Learning Teaching (ALT) includes engaging students through classroom activities, labs, and individual activities. Are there GeoAI techniques that will specifically support and complement existing ALT methods? How can the ALT techniques be implemented within GeoAI education? What methods can be used to successfully evaluate student mastery of GeoAI techniques beyond traditional methods such as exams and final projects?

- Challenge.❶.How.should.Ethics.of.GEOAI.be.included?

Similar to the broader issues with Artificial Intelligence, bias can exist within GeoAI models. Addressing the potential biases and data limitations is a critical component to advancing the field. How to integrate these more non-technical issues within GeoAI education can be complicated. While most of the focus should be on the foundations and technical elements, understanding issues around risks, trust in data, privacy, and copyright restrictions should be included at some level within the curriculum. Using explainable AI techniques and recommending human validation techniques will help to make GeoAI models more transparent to students and less of an unknown to those learning and using the techniques for the first time. Having active discussions with students around these issues will provide clarity on existing challenges and future implications.

Conclusions

This white paper used Wang et al., (2024) as the primary source of information to identify key trends of the use of GeoAI within Geography with Mansourian, A. (2023) as an additional resource to identify current challenges using the technology. The use of AI within Geography is inherently interdisciplinary; bridging the strengths and connections between geospatial techniques, programming, and data science will provide opportunities for technological advancements of complex problems. The challenges identified in this white paper will be important to consider as well as address in future research or before educational engagement is conducted using GeoAI.

References

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