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RESEARCH ARTICLE

Mapping the Present and Future: A Curriculum for Geospatial Artificial Intelligence (GeoAI)

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Abstract
This paper presents a new training curriculum for Geospatial Artificial Intelligence (GeoAI), a rapidly progressing interdisciplinary field that merges spatial science principles with advanced machine learning techniques. The curriculum is designed to prepare future Master of Science and Doctor of Philosophy students in Surveying and Geoinformatics, specializing in Geospatial Artificial Intelligence, with the essential theoretical foundations, practical skills, and ethical considerations necessary for creating and implementing innovative GeoAI solutions. Core courses encompass Geospatial Programming and Automation, spatial data management, Computer Vision for Geospatial Data, machine learning algorithms, GeoAI applications, model evaluation, and ethical guidelines. This curriculum is designed to merge various knowledge domains to develop a group of skilled GeoAI professionals who can effectively address complex real-world Geoinformatics challenges with tailored content for Nigeria's context.

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1. INTRODUCTION

Geospatial Artificial Intelligence (GeoAI) represents innovative approaches that promote Geographical Information Science (GIS) and Earth Observation into a new stage. GeoAI provides powerful learning algorithms such as machine learning, deep learning, and transfer learning to develop effective and innovative solutions for geospatial and Earth issues (Smith, 1984; Janowicz *et al*., 2020; VoPham *et al*., 2018). Mapping is an essential component of GIS and Earth observation that helps in understanding natural and built environments. Traditionally, spatial analysis based on the theories of spatial statistical inference is used for mapping. The issues of spatial analysis can be classified into the following categories: identifying spatial patterns (Thach *et al*., 2018), exploring spatial factors (Luo *et al*., 2022a; Zhang *et al*., 2022b; Song *et al*., 2020; Song and Wu, 2021), spatial interpolation and prediction (Luo *et al*., 2022b; Song, 2022a,b), spatial simulation (Crooks and Castle, 2011; Castle and Crooks, 2006), and geographical decision making (Song *et al*., 2021). GeoAI has significantly enhanced the traditional methods of geospatial analysis and mapping in recent years. They have the potential to transform the way we understand and manage the complex interactions between human and natural systems in the world. GeoAI has greatly improved the approach to addressing complex geospatial and Earth-related challenges. The integration of advanced computational tools provides more opportunities for innovative applications of geospatial artificial intelligence (GeoAI) and Earth observation. These advanced computational tools include big data analysis (Li *et al*., 2016), cloud computing (Yao *et al*., 2019) (such as Google Earth Engine, Gorelick *et al*., 2017), knowledge graphs (Ma, 2022), natural language processing (Sit *et al*., 2019), etc. The integration of these advanced computational tools with geospatial analysis and Earth observation has led to essential advancements in geospatial big data (Yang *et al*., 2020), geospatial cloud computing (Yao *et al*., 2019), and geospatial knowledge graphs (Chadzynski *et al*., 2021). GeoAI has been a driving force in these advancements (Janowicz *et al*., 2020). The rise of GeoAI has introduced a new paradigm in spatial data analysis, enabling the extraction of insights from large and complex geospatial datasets. From natural disaster management to urban planning, the application of GeoAI has become increasingly critical. Despite its growing significance, there is a lack of a structured curriculum that comprehensively integrates geospatial science with artificial intelligence (AI) techniques. The development of such a curriculum is vital for preparing future professionals to navigate the complexities of GeoAI applications in a variety of domains. By explicitly connecting current methodologies to the pioneering contributions of AI luminaries such as Yann LeCun (Convolutional Neural Networks), Ian Goodfellow (Generative Adversarial Networks), Yoshua Bengio and Geoffrey Hinton (Deep Learning Architectures and Backpropagation), and Richard Sutton and Andrew Barto (Reinforcement Learning), This article proposes a detailed curriculum framework for GeoAI, designed to cultivate a strong foundation in both geospatial analysis and AI methodologies, ensuring students and professionals are equipped with the requisite skills for this interdisciplinary field with focus on future Master of Science and Doctor of Philosophy students in Surveying and GeoInformatics with specialization in GeoAI.

2. THE NEED FOR A GEOAI CURRICULUM IN SURVEYING AND GEOINFORMATICS

The convergence of geospatial technologies and artificial intelligence (AI) is rapidly transforming how we understand and interact with our world. From autonomous vehicles navigating complex urban landscapes to precision agriculture optimizing resource allocation, Geospatial AI is driving innovation across diverse sectors. However, realizing the full potential of this powerful synergy requires a new generation of professionals equipped with the necessary interdisciplinary skills. This necessitates a thoughtfully designed curriculum for Geospatial Artificial Intelligence.

Furthermore, the importance of geospatial data in decision-making processes is growing exponentially. As more industries and governmental organizations leverage geospatial data for predictive modelling, environmental monitoring, and infrastructure development, the need for professionals proficient in both GIS and AI is evident. However, most current educational programs focus separately on either geospatial sciences or AI, leaving a gap in holistic educational frameworks. A GeoAI curriculum addresses this gap by: Bridging the divide between geospatial sciences and artificial intelligence, preparing students to work with advanced machine learning and data analytics techniques on geospatial data, and promoting the integration of emerging technologies like remote sensing, LiDAR, and UAVs in AI-driven geospatial research.

3. CORE COMPONENTS OF A GEOAI CURRICULUM

A curriculum would not simply be the sum of existing geospatial science and AI programs. It requires a unique, integrated approach that bridges the gap between understanding spatial data and leveraging the power of machine learning. Here's a blueprint for what a comprehensive curriculum for Geospatial AI at the MSc and PhD levels could look like:

MSc Curriculum for Geospatial Artificial Intelligence

This curriculum outlines a comprehensive Master of Science program in Geospatial Artificial Intelligence, equipping students with the knowledge and skills to leverage AI and machine learning techniques for analyzing and understanding spatial data.

Program Goals:

I. Develop a strong foundation in both geospatial science and artificial intelligence.

II. Equip students with theoretical and practical knowledge of applying AI/ML techniques to geospatial data.

III. Foster critical thinking and problem-solving skills in the context of geospatial challenges.
IV. Prepare graduates for research and professional careers in academia, government, and industry.
V. Promote ethical and responsible development and application of geospatial AI technologies.

Program Structure (Typical 2-Year Program):

This is a modular structure, and specific course titles and content might vary depending on the institution.

Year 1: Foundations

Semester 1:

Geospatial Foundations:
i. Geographic Information Systems (GIS): Principles, data models, spatial analysis techniques, software proficiency (e.g., ArcGIS, QGIS).
ii. Remote Sensing and Image Analysis: Fundamentals of remote sensing, image acquisition, pre-processing, and basic interpretation.
iii. Spatial Data Structures and Algorithms: Understanding how spatial data is stored and manipulated, including spatial indexing, querying, and data integration.
iv. Mathematics for Geospatial Analysis: Linear algebra, calculus, probability, and statistics relevant to spatial data, Graph Theory, and Topology

Artificial Intelligence Fundamentals:
i. Introduction to Artificial Intelligence: History, core concepts, problem-solving techniques, intelligent agents.
ii. Introduction to Machine Learning: Supervised, unsupervised, and reinforcement learning principles, model evaluation, and common algorithms.
iii. Programming for Data Science (Python Emphasis): Data manipulation libraries (e.g., Pandas, NumPy), visualization (e.g., Matplotlib, Seaborn), and basic ML libraries (e.g., Scikit-learn).

Elective Courses (Choose 1-2 based on specialization):
i. Advanced Remote Sensing Analysis: Hyperspectral imaging, LiDAR, SAR data processing, and analysis.
ii. Urban Analytics and Smart Cities: Applying geospatial AI for urban planning, transportation, and resource management.
iii. Environmental Modeling and Prediction: Using AI for environmental monitoring, forecasting, and climate change analysis.
iv. Geospatial AI for Disaster Response and Humanitarian Aid: Applications in mapping, damage assessment, and resource allocation.
v. Geospatial Robotics and Autonomous Systems: Integration of AI with robotic platforms for spatial data acquisition and analysis.

Semester 2:

Advanced Geospatial Techniques:
i. Spatial Statistics and Geostatistics: Modeling spatial dependencies, spatial autocorrelation, kriging, and other geostatistical methods.
ii. Geospatial Data Management and Databases: Spatial databases (e.g., PostGIS), data warehousing, cloud-based geospatial platforms.
iii. Geospatial Programming and Automation: Developing custom GIS tools, scripting, and automating geospatial workflows.

Artificial Intelligence Deep Dive:
i. Deep Learning: Neural networks, convolutional neural networks (CNNs), recurrent neural networks (RNNs), and their applications.
ii. Natural Language Processing (NLP) Fundamentals: Text analysis, sentiment analysis, geocoding from text, and applications in a geospatial context.

iii. Computer Vision: Image processing, object detection, image segmentation, and applications for analyzing satellite and aerial imagery, Object-Based Image Analysis (OBIA).

Core Geospatial AI Courses:

i. Geospatial Machine Learning: Applying ML algorithms to spatial data, spatial feature engineering, and handling spatial autocorrelation in ML models.
ii. Computer Vision for Geospatial Data: Advanced techniques for image analysis, object detection, change detection, and scene understanding from remote sensing data.
iii. Spatial Data Mining and Knowledge Discovery: Techniques for extracting patterns and insights from large geospatial datasets.
iv. Ethical and Societal Implications of Geospatial AI: Bias in data and algorithms, privacy concerns, responsible development and deployment of geospatial AI.

Year 2: Research

Semester 3:

Research and Capstone Project:

i. Research Methods in Geospatial AI: Designing research studies, data collection and analysis, and scientific writing.
ii. Capstone Project: A significant independent research project applying geospatial AI techniques to a real-world problem. This involves problem definition, literature review, methodology development, data analysis, and report writing.

- Elective Courses (Choose 1-2 based on specialization):

i. Cloud Computing for Geospatial AI: Utilizing cloud platforms for data storage, processing, and model deployment.
ii. Time Series Analysis of Geospatial Data: Analyzing spatio-temporal patterns and trends.
iii. Geospatial Simulation and Modeling: Developing AI-driven simulations of spatial processes.
iv. Explainable AI (XAI) for Geospatial Applications: Making AI models more transparent and interpretable in the geospatial domain.
v. Business Intelligence and Geospatial Analytics: Applying AI for location-based business decisions and market analysis.

Assessment Methods:

i. Assignments (programming exercises, data analysis tasks, report writing)
ii. Midterm and final exams
iii. Project proposals, progress reports, and final presentations
iv. Class participation and discussions
v. Capstone project report and defense

Required Skills and Background:

I. A bachelor's degree in a relevant field such as:
a. Geospatial Science/Engineering (GIS, Remote Sensing, Geomatics)
b. Computer Science
c. Data Science
d. Environmental Science
e. Geography
f. Mathematics or Statistics
II. Strong analytical and problem-solving skills
III. Basic programming experience (preferably Python)
IV. A strong interest in the intersection of geospatial technologies and artificial intelligence

Software and Tools Proficiency:

Students will be expected to gain proficiency in various software and tools, including but not limited to:

I. GIS Software: ArcGIS Pro, QGIS
II. Remote Sensing Software: ENVI, Google Earth Engine
III. Programming Languages: Python (essential), R (optional)
IV. Data Science Libraries: Pandas, NumPy, Scikit-learn, Matplotlib, Seaborn
V. Deep Learning Frameworks: TensorFlow, Keras, PyTorch
VI. Spatial Data Libraries: GeoPandas, PySAL, Shapely, Rasterio
VII. Cloud Computing Platforms (Optional): Google Cloud Platform (GCP), Amazon Web Services (AWS), Microsoft Azure, Add OpenStreetMap (OSM) APIs, and GitHub

Career Prospects:

Graduates of this MSc program will be well-equipped for a variety of careers in:
I. Geospatial Industry: GIS Analyst, Remote Sensing Specialist, Geospatial Data Scientist, AI Engineer for geospatial applications.
II. Technology Companies: Developing AI-powered geospatial products and services.
III. Government Agencies: Environmental monitoring, urban planning, disaster management, and national security.
IV. Research Institutions: Conducting research in geospatial AI and related fields.
V. Consulting Firms: Providing geospatial AI expertise to various industries.
VI. Non-profit Organizations: Applying geospatial AI for humanitarian aid and development.

PhD Curriculum in Geospatial Artificial Intelligence

This curriculum outlines a potential path for a PhD student specializing in Geospatial Artificial Intelligence. It blends foundational knowledge in both geospatial sciences and artificial intelligence, focusing on the intersection and application of AI to spatial data and problems. The specific courses and their emphasis may vary depending on the university and the student's research interests.

Program Structure (Typical 3-Year Program):

This section is divided into three Core AI Courses but a total of six courses are required.

Year 1, Semester 1 & 2: Core AI Courses:

Advanced Machine Learning:
I. Supervised Learning (Regression, Classification, Ensemble Methods)
II. Unsupervised Learning (Clustering, Dimensionality Reduction, Anomaly Detection)
III. Deep Learning (Convolutional Neural Networks, Recurrent Neural Networks, Generative Models)
IV. Statistical Learning Theory
V. Model Evaluation and Selection

Probabilistic Graphical Models:
I. Bayesian Networks, Markov Random Fields
II. Inference Algorithms (Exact and Approximate)
III. Applications in Spatial Reasoning and Uncertainty Modeling

Artificial Intelligence Foundations:
I. Knowledge Representation and Reasoning
II. Search Algorithms and Optimization
III. Logic and Automated Reasoning
IV. Ethical Considerations in AI Development and Deployment

Computer Vision:
V. Image Processing and Analysis
VI. Feature Extraction and Matching
VII. Object Detection and Recognition
VIII. Scene Understanding

IX. Applications in Remote Sensing and Geospatial Imagery

Year 1, Semester 1 & 2: Core Geomatics Courses:

Advanced Spatial Data Science:
I. Spatial Data Structures and Algorithms
II. Spatial Statistics / Geostatistics
III. Spatial Databases and Management
IV. Geospatial Data Mining and Knowledge Discovery

Advanced Remote Sensing:
i. Digital Image Processing Techniques
ii. Hyperspectral and Multispectral Analysis
iii. Radar and LiDAR Data Processing
iv. Change Detection and Time Series Analysis

Advanced Geographic Information Systems (GIS):
i. Geoprocessing Workflow Design and Automation
ii. Web GIS and Spatial Data Infrastructure

Advanced Geodesy and Positioning:
i. Satellite Positioning (GNSS Theory and Applications)
ii. Inertial Navigation Systems
iii. Precise Point Positioning (PPP)
iv. Geodetic Datum and Coordinate Systems
v. Integrate SLAM (Simultaneous Localization and Mapping)
vi. Geodynamics and Earth Observation

Year 1, Semester 1 & 2: Integrated AI and Geomatics Courses:

Spatial Data Science with Machine Learning:
I. Applying machine learning techniques to geospatial data
II. Integrating spatial context into AI models
III. Feature engineering for spatial data analysis
IV. Developing AI-powered geospatial applications

AI for Remote Sensing Image Analysis:
i. Deep learning for object detection and scene classification in remote sensing imagery
ii. Semantic segmentation of remote sensing data
iii. Fusion of multi-sensor remote sensing data with AI
iv. Developing automated interpretation workflows

AI in GIS and Spatial Modeling:
i. Using AI for predictive spatial modeling and simulation
ii. Agent-based modeling with AI agents
iii. Integration of AI algorithms within GIS software
iv. Developing intelligent GIS applications

Year 2, Semester 1: Research

This phase focuses on in-depth exploration of specific research areas and the development of independent research capabilities.

Research Methodology in AI and Geomatics:
i. Scientific research design and methods
ii. Hypothesis formulation and testing
iii. Data collection and analysis techniques

iv. Evaluation of metrics and validation strategies
v. Responsible research practice

Teaching Assistantships: Opportunities to gain teaching experience by assisting faculty with undergraduate and graduate courses

Research Seminars:
vi. Presentations and discussions of current research in AI and Geomatics
vii. Guest lectures by leading experts
viii. Critical analysis of scientific literature
ix. Development of presentation and communication skills

Independent Study and Research:
x. Focused research under the guidance of a supervisor
xi. Exploration of specific research questions and methodologies
xii. Development of novel algorithms, techniques, or applications

Dissertation Proposal Development:
xiii. Defining the research problem and objectives
xiv. Conducting a comprehensive literature review
xv. Outlining the research methodology and expected outcomes
xvi. Defending the dissertation proposal

Year 2 & 3: Dissertation and Defence

Dissertation Research:
i. Conducting original and significant research in the chosen area
ii. Documenting the research process and findings
iii. Writing the doctoral dissertation

Dissertation Writing and Submission:
i. Adhering to university formatting guidelines
ii. Effectively communicating research findings
iii. Submitting the dissertation for review

Dissertation Defense:
A. Presenting the research findings to a committee of experts
B. Answering questions and defending the research contributions
C. Conference Presentations & Publications: Students are expected to present their research findings at national and international conferences and publish them in peer-reviewed journals.

4.0 CHALLENGES AND RECOMMENDATIONS

To prepare for the future of geospatial AI, we should:
i. Foster interdisciplinary collaborations between geospatial scientists, AI researchers, and domain experts.
ii. Encourage lifelong learning and continuous professional development to keep up with rapidly evolving technologies.
iii. Promote ethical guidelines and best practices for responsible geospatial AI development and deployment.
iv. Expand the geospatial AI curriculum to include emerging disciplines and integrate emerging tools and techniques.
v. Provide accessible and engaging platforms for learners to gain hands-on experience with geospatial AI technologies.
vi. Compute Gap." Most universities in developing regions lack the high-end GPUs (e.g., NVIDIA A100s)

By addressing these challenges and recommendations, we can ensure that the geospatial AI community is well-equipped to tackle the complex spatial challenges of today and tomorrow.

5.0 CONCLUSION

A well-designed curriculum for Geospatial Artificial Intelligence is more than just an educational endeavor. It's an investment in the future, equipping the next generation of professionals with the skills to navigate the complexities of our world and unlock the immense potential of geospatial data. By fostering a deep understanding of both spatial analysis and artificial intelligence, we can empower individuals to map the present with clarity and build a more informed and sustainable future for all. The journey of developing this curriculum is a continuous one, but the potential impact on our understanding of the world is immeasurable.

REFERENCES

Castle, C. J., & Crooks, A. T. (2006). *Principles and concepts of agent-based modelling for developing geospatial simulations*. Centre for Advanced Spatial Analysis, University College London.

Chadzynski, A., Krdzavac, N., Farazi, F., Lim, M. Q., Li, S., Grisiute, A., Herthogs, P., von Richthofen, A., Cairns, S., & Kraft, M. (2021). Semantic 3D city database—An enabler for a dynamic geospatial knowledge graph. *Energy AI, 6*, 100106. https://doi.org/10.1016/j.egyai.2021.100106

Crooks, A. T., & Castle, C. J. (2011). The integration of agent-based modelling and geographical information for geospatial simulation. In A. Heppenstall, A. Crooks, L. See, & M. Batty (Eds.), *Agent-based models of geographical systems* (pp. 219–251). Springer.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment, 202*, 18–27.

Janowicz, K., Gao, S., McKenzie, G., Hu, Y., & Bhaduri, B. (2020). GeoAI: Spatially explicit artificial intelligence techniques for geographic knowledge discovery and beyond. *International Journal of Geographical Information Science*.

LeCun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998). Gradient-based learning applied to document recognition. *Proceedings of the IEEE, 86*(11), 2278–2324.

Li, S., Dragicevic, S., Castro, F. A., Sester, M., Winter, S., Çöltekin, A., Pettit, C., Jiang, B., Haworth, J., & Stein, A. (2016). Geospatial big data handling theory and methods: A review and research challenges. *ISPRS Journal of Photogrammetry and Remote Sensing, 115*, 119–133. https://doi.org/10.1016/j.isprsjprs.2016.01.001

Luo, P., Song, Y., Huang, X., Ma, H., Liu, J., Yao, Y., & Meng, L. (2022a). Identifying determinants of spatio-temporal disparities in soil moisture of the Northern Hemisphere using a geographically optimal zones-based heterogeneity model. *ISPRS Journal of Photogrammetry and Remote Sensing, 185*, 111–128.

Luo, P., Song, Y., Zhu, D., Cheng, J., & Meng, L. (2022b). A generalized heterogeneity model for spatial interpolation. *International Journal of Geographical Information Science*, 1–26.

Ma, X. (2022). Knowledge graph construction and application in geosciences: A review. *Computers & Geosciences*, 105082.

Sit, M. A., Koylu, C., & Demir, I. (2019). Identifying disaster-related tweets and their semantic, spatial, and temporal context using deep learning, natural language processing, and spatial analysis: A case study of Hurricane Irma. *International Journal of Digital Earth, 12*(11), 1205–1229.

Smith, T. R. (1984). Artificial intelligence and its applicability to geographical problem solving. *The Professional Geographer, 36*(2), 147–158.

Song, Y. (2022a). Geographically optimal similarity. *Mathematical Geosciences*, 1–26.

Song, Y. (2022b). The second dimension of spatial association. *International Journal of Applied Earth Observation and Geoinformation, 111*, 102834.

Song, Y., Thatcher, D., Li, Q., McHugh, T., & Wu, P. (2021). Developing sustainable road infrastructure performance indicators using a model-driven fuzzy spatial multi-criteria decision-making method. *Renewable and Sustainable Energy Reviews, 138*, 110538.

Song, Y., Wang, J., Ge, Y., & Xu, C. (2020). An optimal parameters-based geographical detector model enhances geographic characteristics of explanatory variables for spatial heterogeneity analysis: Cases with different types of spatial data. *GIScience & Remote Sensing, 57*(5), 593–610.

Song, Y., & Wu, P. (2021). An interactive detector for spatial associations. *International Journal of Geographical Information Science, 35*(8), 1676–1701.

Thach, N. N., Ngo, D. B.-T., Xuan-Canh, P., Hong-Thi, N., Thi, B. H., Nhat-Duc, H., & Dieu, T. B. (2018). Spatial pattern assessment of tropical forest fire danger at Thuan Chau area (Vietnam) using GIS-based advanced machine learning algorithms: Comparative study. *Ecological Informatics, 46*, 74–85.

VoPham, T., Hart, J. E., Laden, F., & Chiang, Y.-Y. (2018). Emerging trends in geospatial artificial intelligence (GeoAI): Potential applications for environmental epidemiology. *Environmental Health, 17*(1), 1–6.

Yang, M., Kong, B., Dang, R., & Yan, X. (2022). Classifying urban functional regions by integrating buildings and points of interest using a stacking ensemble method. *International Journal of Applied Earth Observation and Geoinformation, 108*, 102753.

Yao, X., Li, G., Xia, J., Ben, J., Cao, Q., Zhao, L., Ma, Y., Zhang, L., & Zhu, D. (2019). Enabling big earth observation data via cloud computing and DGGS: Opportunities and challenges. *Remote Sensing, 12*(1), 62.

Zhang, Z., Song, Y., & Wu, P. (2022). Robust geographical detector. *International Journal of Applied Earth Observation and Geoinformation, 109*, 102782.