GeoAI and the Future of Mapping

Dr. Song Gao
University of Wisconsin–Madison
National AI Institute: ICICLE

Email: song.gao@wisc.edu
https://geods.geography.wisc.edu/
"It is not often that geography is touched by a development having the potential to affect substantially all of the practical, technical, methodological, theoretical and philosophical aspects of our work."

- Helen Couclelis (1986)
AI in Geographical Sciences

- Spatial scene classification
- Geographic object detection and localization
- Spatial interpolation and downscaling
- Spatiotemporal predictions and modeling
- Multisource and multimodal data fusion
- Linking physical models and machine learning

Reichstein et al. (2019, Nature)
Brown et al. (2022, Sci. Data)
Li & Hsu (2020, IJGIS)
Zhu et al. (2020, IJGIS)
Li, Gao et al. (2021, IJGIS)
Challenges and Issues on GeoAI

- Biases
- Explainability
- Ethics and Privacy
- Reproducibility and Replicability
- Responsibility and Trustworthiness
- Sustainability
Biases

- **Model bias** (data, population demographics, global vs. local)
- **Perception bias** (experience, local knowledge)

Kang et al. (2023, Landscape and Urban Planning)
Weak Replicability

- Spatial heterogeneity
- Distribution shift across space over time (out-of-distribution)

Goodchild & Li (2021, PNAS), Kedron, Hoffman, & Bardin (2023, Handbook of GeoAI), Koh et al. (2020, arXiv)
Privacy: Location Protection

Rao, Gao, Kang, & Huang. (2021, GIScience)
Privacy: Federated Learning

Rao, Gao, Li, & Huang. (2021, TGIS)
Sustainability

- Carbon emissions, energy and water consumption in AI model training
- Inter-generational prioritization of how to utilize resources across space

Common carbon footprint benchmarks

<table>
<thead>
<tr>
<th>Activity</th>
<th>CO2 Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundtrip flight b/w NY and SF (1 passenger)</td>
<td>1,984</td>
</tr>
<tr>
<td>Human life (avg. 1 year)</td>
<td>11,023</td>
</tr>
<tr>
<td>American life (avg. 1 year)</td>
<td>36,156</td>
</tr>
<tr>
<td>US carbon footprint (1 lifetime)</td>
<td>126,000</td>
</tr>
<tr>
<td>Transformer (213M parameters) w/ neural architecture search</td>
<td>626,155</td>
</tr>
</tbody>
</table>

Chart: MIT Technology Review • Source: Strubell et al. • Created with Datawrapper
Moonshot: Can we develop an artificial GIS analyst that passes a domain-specific Turing Test by 2030?
GeoAI Foundational Model

Mai et al. (2023)
GeoAI-Enabled GIS Assistant: Data and Workflow

Tell me the percentage of water bodies within 10km buffer distance of the State Capital of Wisconsin

I'm sorry, but I don't have access to the most up-to-date geospatial data to answer your question. However, I can guide you on how to obtain this information.

You can use Geographic Information System (GIS) software, such as ArcGIS or QGIS, to analyze the proximity of water bodies to the State Capital of Wisconsin. You will need to obtain a shapefile or dataset of water bodies within Wisconsin and another shapefile or dataset of the State Capital of Wisconsin.

Once you have both datasets, you can use the buffer tool to create a 10km buffer around the State Capital of Wisconsin. Then, you can use a spatial join or intersect tool to calculate the percentage of water bodies within the 10km buffer distance.

Alternatively, you can search for existing studies or reports that have already calculated this information. The Wisconsin Department of Natural Resources or the Wisconsin Geological and Natural History Survey may have information that could be helpful.
GeoAI-Enabled Cartography Assistant

Prompt:
A {MapType} of {Region} on {Place} with {Description}

- Inaccuracy
- Misleading information
- Unexpected features
- Non-reproducibility
National AI institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment (ICICLE)

https://icicle.ai/
Thank you!

- AI <-> Geography (Spatially explicit AI methods)
- Bias, Replicability, Privacy, Sustainability Issues
- GeoAI Foundational Models