A Review and Synthesis of Recent GeoAI Research for Cartography: Methods, Applications, and Ethics

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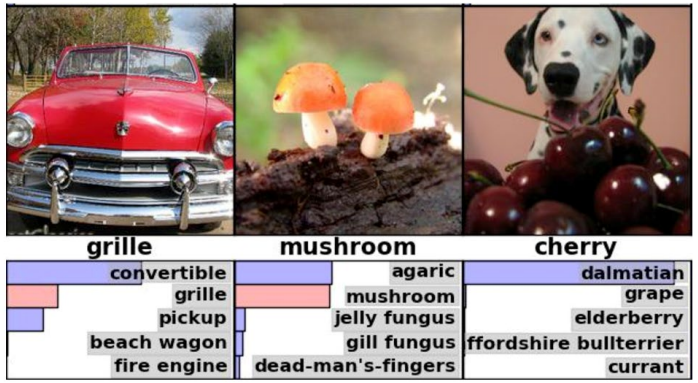
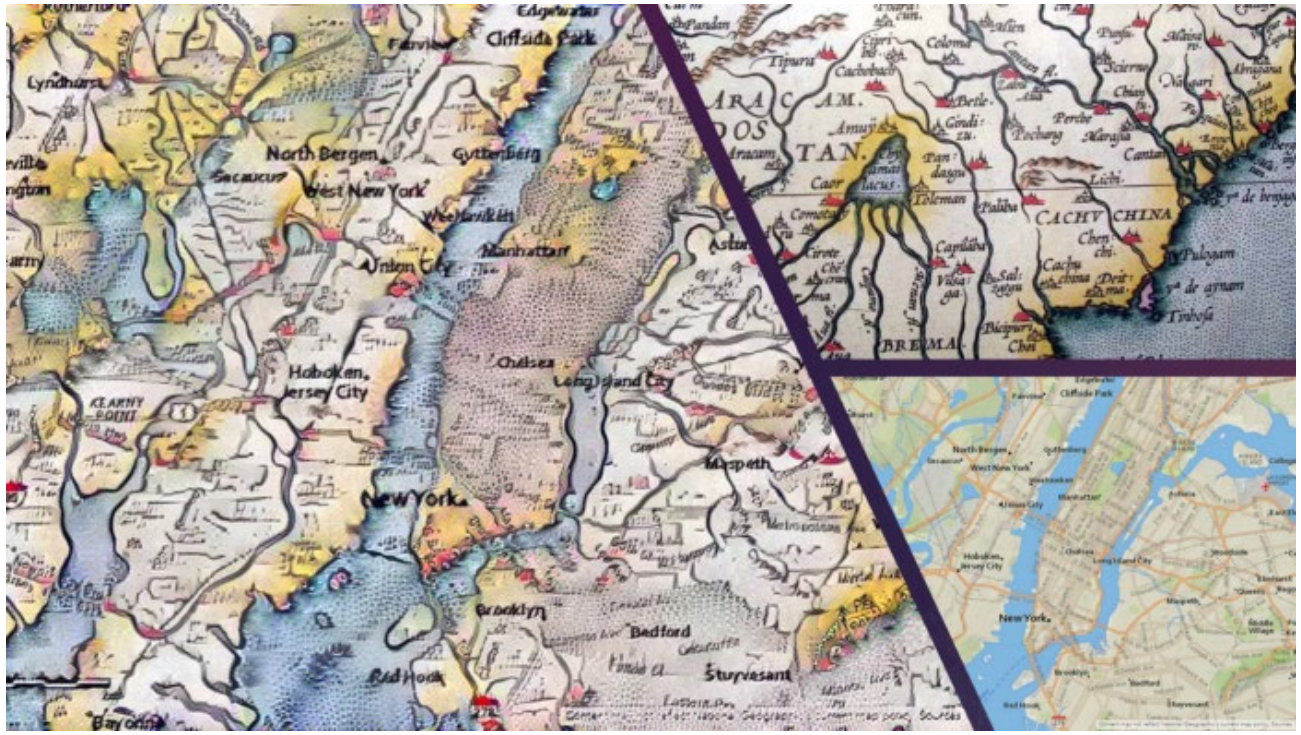
The Booming AI



Deep Learning for Object Detection from Images

AlphaGo with Deep Learning

GeoAI: The integration of geospatial studies and AI

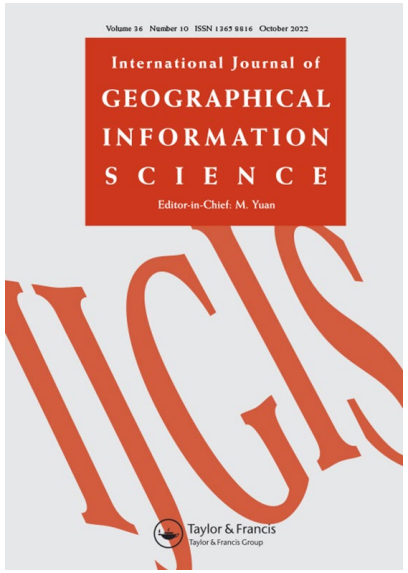


Transfer Map Styles with GeoAI

Gao, S., 2021. *Geospatial Artificial Intelligence (GeoAI)*. Oxford University Press.

Singh, R., 2019. *Integrating Deep Learning with GIS*.

GeoAI for Cartography



GeoAI

Can we develop an artificial GIS analyst that passes a domain-specific Turing Test by 2030?

Janowicz, K. et al., 2020. GeoAI: spatially explicit artificial intelligence techniques for geographic knowledge discovery and beyond. *International Journal of Geographical Information Science*.

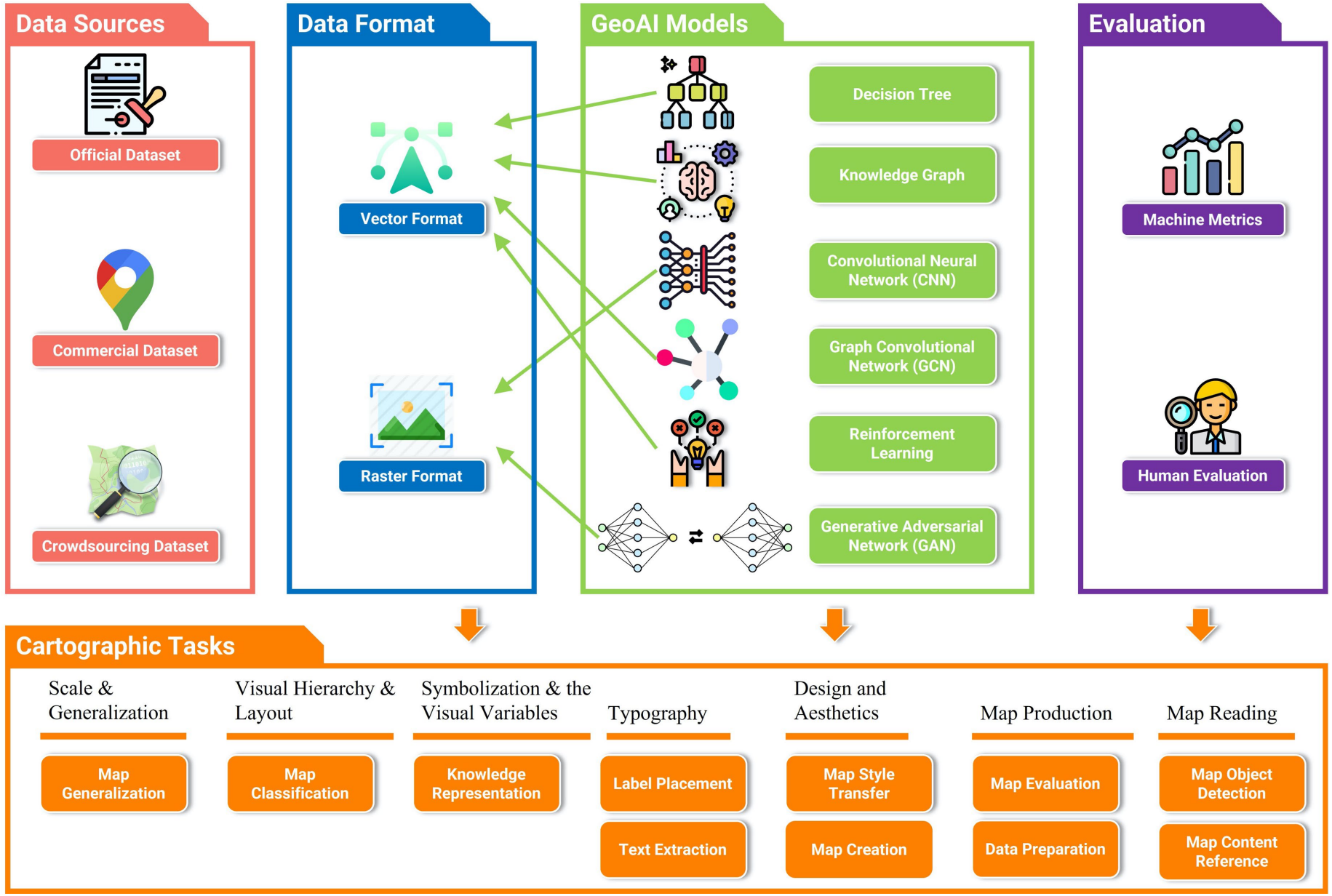
GeoAI for Cartography

Can we develop an artificial cartographer assistant so that cartographers are no longer focused on the usage of cartographic tools and technical details but more on artistic map creation?

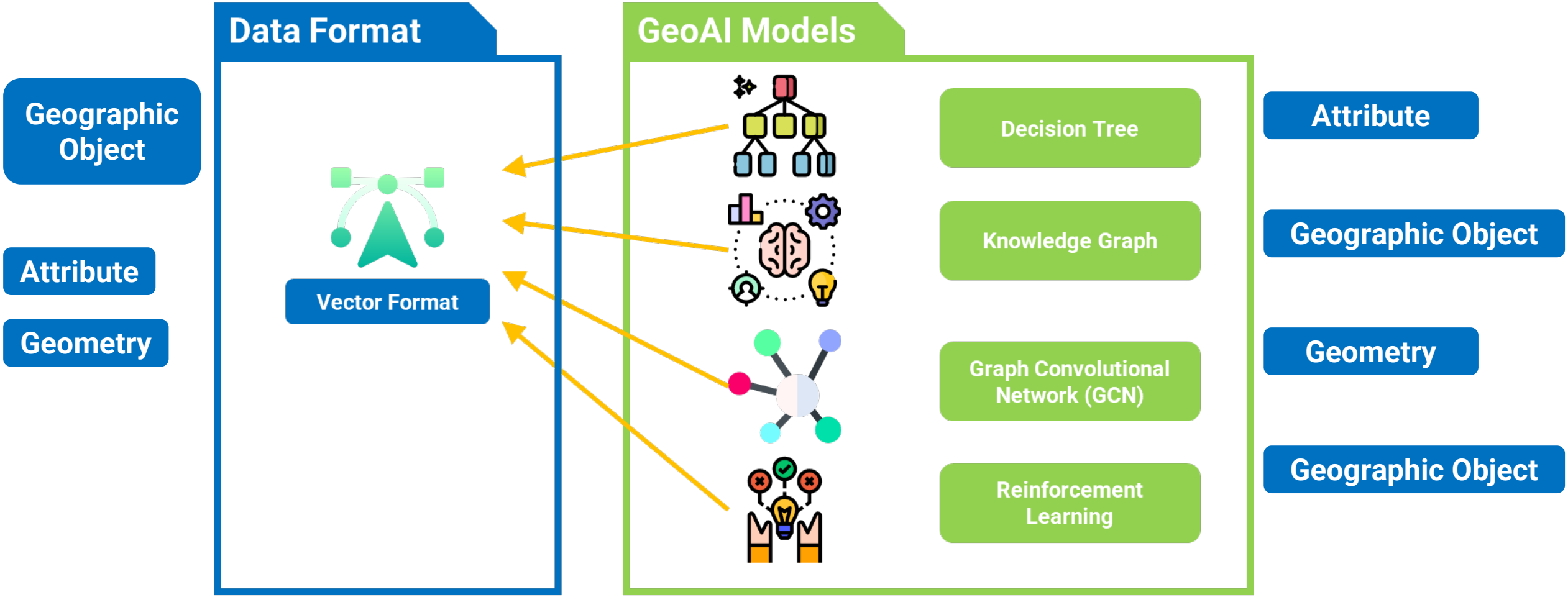
Computational Framework

Scopus

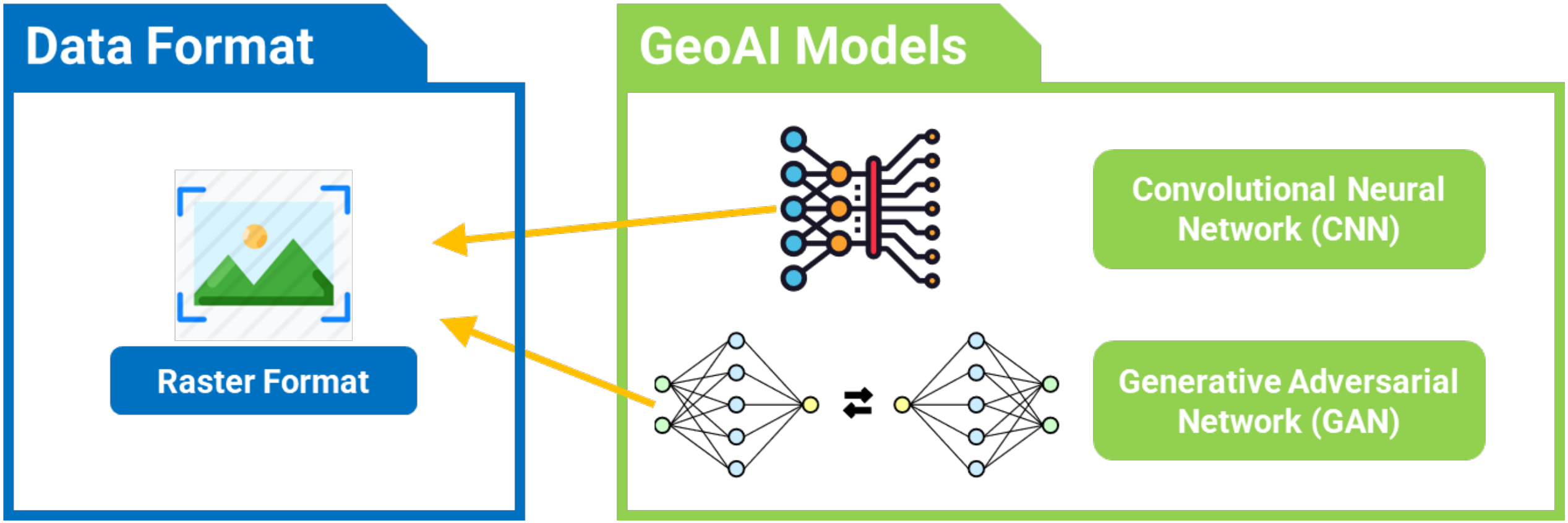
82 Papers



GeoAI Approaches for Vector Data



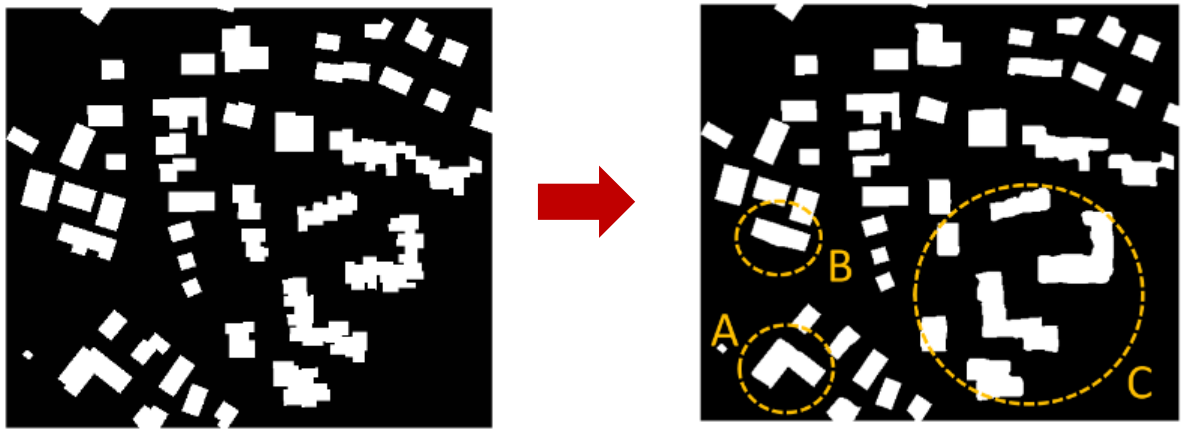
GeoAI Approaches for Raster Data



Applications: Map Generalization

Tasks

Simplification



Smooth

Methods

- Decision Tree
- Convolutional Neural Network (CNN)
- Generative Adversarial Network (GAN)
- Graph Convolutional Network (GCN)

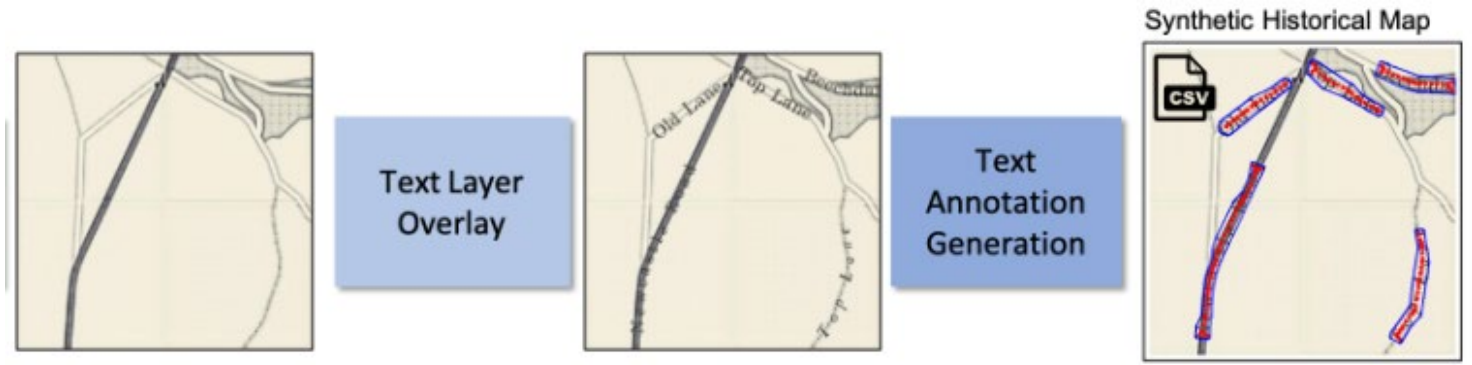
Feng, Y., et al., 2019. Learning cartographic building generalization with deep convolutional neural networks. *ISPRS International Journal of Geo-Information*.
Courtial, A., et al., 2020. Exploring the potential of deep learning segmentation for mountain roads generalisation. *ISPRS International Journal of Geo-Information*.

Applications: Typography

Tasks

Automatically place labels

Automatically generate map labels



Methods

- Generative Adversarial Network (GAN)
- Convolutional Neural Network (CNN)
- Reinforcement Learning

Pokonieczny, K. et al., 2019. Using artificial neural network for labelling polygon features in topographic maps. *GeoScape*.

Li, Z., Guan, R., Yu, Q., Chiang, Y.Y. and Knoblock, C.A., 2021, November. Synthetic Map Generation to Provide Unlimited Training Data for Historical Map Text Detection. In *Proceedings of the 4th ACM SIGSPATIAL International Workshop on AI for Geographic Knowledge Discovery* (pp. 17-26).

Applications: Design and Aesthetics

Tasks

Map Style Transfer

Simple styled maps

Transfer styled maps

Target styled maps

"Deep Fake Geography"

Urban Structure

Fake Image

Methods

Generative Adversarial Network (GAN)

Convolutional Neural Network (CNN)

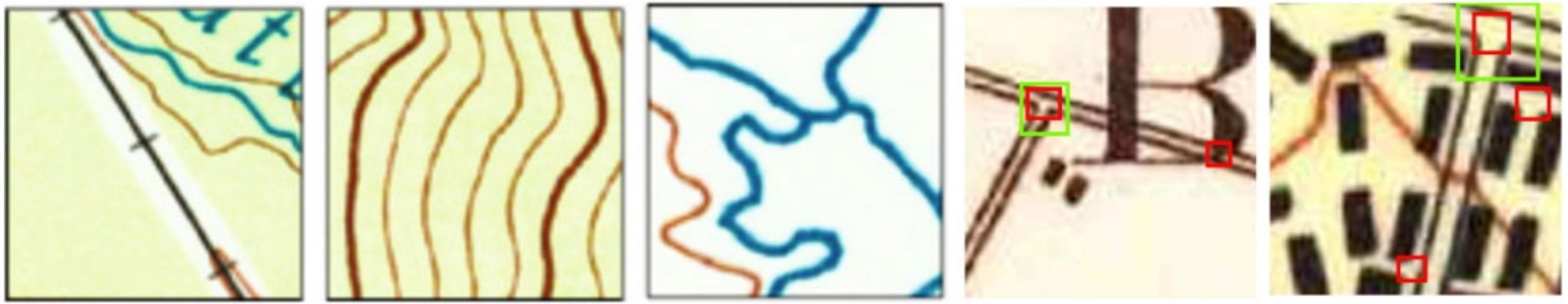
Kang, Y., et al., 2019. Transferring multiscale map styles using generative adversarial networks. *International Journal of Cartography*.

Zhao, B., et al., 2021. Deep fake geography? When geospatial data encounter Artificial Intelligence. *Cartography and Geographic Information Science*.

Applications: Map Reading

Tasks

Map Object Detection



Methods

- Convolutional Neural Network (CNN)
- Graph Convolutional Network (GCN)

Chiang, Y.Y., et al., 2020. Training deep learning models for geographic feature recognition from historical maps. In *Using historical maps in scientific studies*.

Saeedimoghaddam, et al., 2020. Automatic extraction of road intersection points from USGS historical map series using deep convolutional neural networks. *International Journal of Geographical Information Science*.

Applications: Map Reading

Tasks

Map Content Reference

Iran
0.999

Andorra
0.991

Finland
0.999

Argentina
0.998

Nepal
0.991

Italy
0.998

Find Similar Regions

Methods

Convolutional Neural Network (CNN)

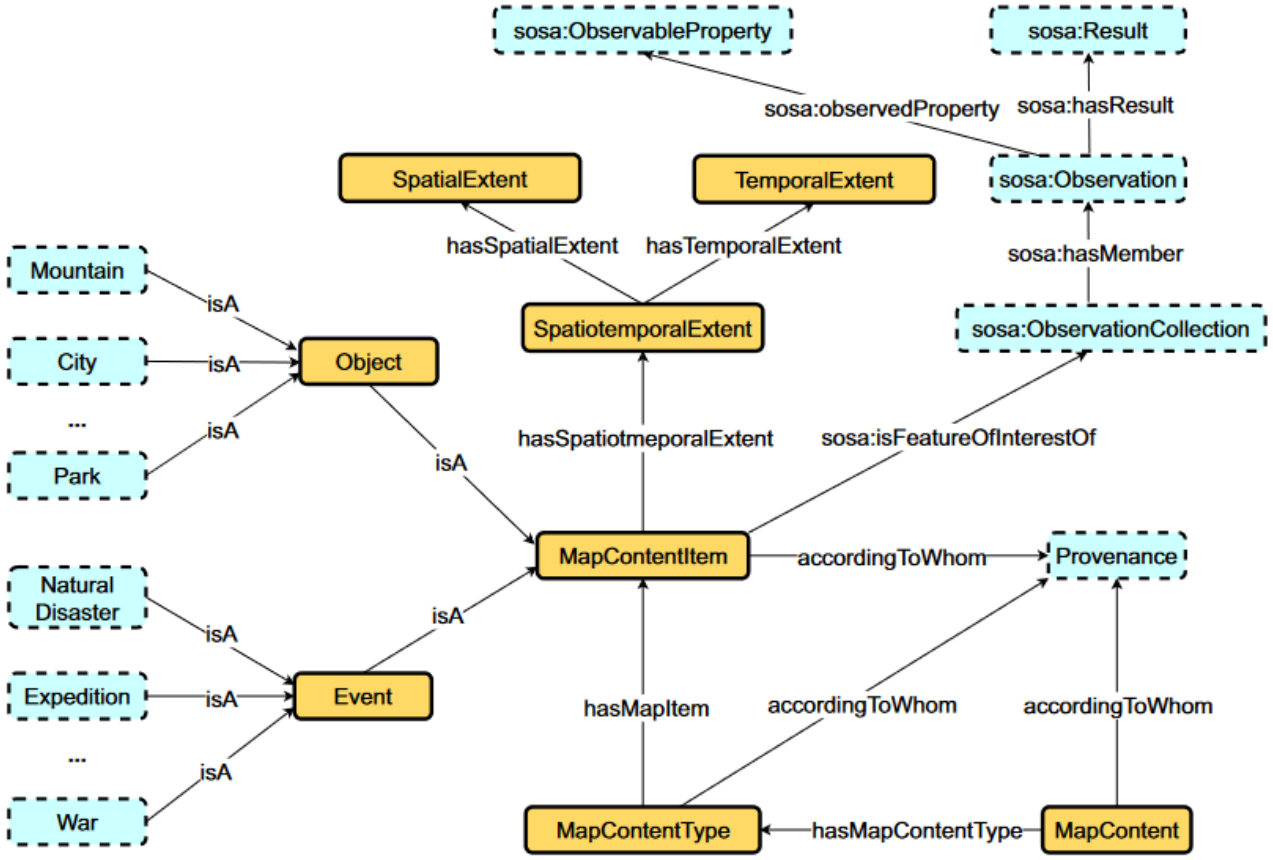
Evans, M.R., et al., 2017, November. Livemaps: Learning geo-intent from images of maps on a large scale. In *Proceedings of the 25th ACM SIGSPATIAL international conference on advances in geographic information systems*.

Dobesova, Z., 2020. Experiment in finding look-alike European cities using urban atlas data. *ISPRS International Journal of Geo-Information*.

Applications: Knowledge Representation

Tasks

Summarize Cartographic Knowledge




```
@[prefix definitions]
CONSTRUCT {?battle symbolizer:isSymbolizedBy portrayal:
    ↪ symbolizer_3}
WHERE
{
  ?battle wdt:P31 wd:Q178561.              # the entity is a battle
  {wd:Q362 wdt:P527* ?battle .}            # the entity is x-degree
     ↪ away from the World War II node with ''has part'' relation
  union
  {?battle wdt:P361* wd:Q362 .}            # the entity is x-degree
     ↪ away from the World War II node with reverse ''part of''
     ↪ relation
  ?battle wdt:P580 ?start_time .           # Query the battle's
     ↪ start time
  FILTER(?start_time > "1939-01-01T00:00:000"^^xsd:dateTime)  #
     ↪ Keep the battles whose start time is later than Jan 1,
     ↪ 1939
  FILTER(?start_time < "1940-01-01T00:00:000"^^xsd:dateTime)  #
     ↪ Keep the battles whose start time is earlier than Jan 1,
     ↪ 1940
}
order by ?start_time
```

Methods

Knowledge Graph

Mai, G., et al., 2022. Narrative Cartography with Knowledge Graphs. *Journal of Geovisualization and Spatial Analysis*, *6*(1), pp.1-24.

Ethics in GeoAI for Cartography

Commodification

Charging issues of dataset, visual styles, and generalization outcomes

The copyright and responsibility issue for the cartographic outcomes produced by GeoAI

Bias

Toward trustworthy cartographic results generated by GeoAI

Biased dataset (e.g., spatial bias, population bias)

Interpretability

The “black-box” issue of the GeoAI in cartography

Discussion

When should we use GeoAI for cartography?

How to integrate cartographers' experience into GeoAI for cartography?

What would be the big picture of GeoAI for cartography?

Promote the Global Cartography/GIS Education

The GISphere Project

The GISphere Project has summarized more than 400 Cartography/GIS-related programs (e.g., urban planning, remote sensing) in more than 70 countries or regions across the world

Programs

University of Wisconsin-Madison

Madison, Wisconsin, USA

Unit: Department of Geography

The geography department at UW-Madison has a long history and is a powerhouse in human geography, spatial analysis, and cartography. Famous Chinese-American geographer Yi-Fu Tuan and cartographer Arthur Robinson worked here. There are 2 types of GIS-related programs in this department. The research-based program is for those who want to land a carrer in academia. Those who have completed their undergraduate studies could enter the joint Masters/PhD (2 + 3 years) program while those who have a master's degree could enter the 4-year PhD program. The course-based program is for those who want to work for the industry. GIS-related courses include cartography, spatial analysis, geospatial big data, etc.

Twitter: GISphere
YouTube: GISphere
Website:
https://gisphere.github.io/

Professors

Professors:

- A-Xing Zhu: soil mapping, ecology, spatial analysis, environment modeling;
- Song Gao: spatio-temporal data mining, human mobility, urban computing, GeoAI;
- Qunying Huang: high performance computing, natural hazards, social media data analytics;
- Robert Roth: cartography, story map, WebGIS;
- Christian Andresen: arctic ecosystems, remote sensing, surface hydrology, wetlands, environmental change, carbon cycling, geospatial analytics, LiDAR, photogrammetry, unmanned aerial systems;
- John W. (Jack) Williams: paleoecoinformatics, geo-cyberinfrastructure, paleoecology, paleoclimatology, novel ecosystems, vegetation dynamics, global climate change, quaternary environments;
- Zhou Zhang (Department of Biological System Engineering): multi-source remote sensing, LiDAR, digital agriculture;
- Anna Pidgeon (Department of Forest & Wildlife Ecology): ecological field work, remote sensing, GIS, statistics;
- Volker C. Radeloff (Department of Forest & Wildlife Ecology): biodiversity, spatial analysis;
- Tristan L'Ecuyer (Department of Atmospheric and Oceanic Sciences): remote sensing, arctic climate;
- Steve Ackerman (Department of Atmospheric and Oceanic Sciences): remote sensing, cloud physics, climate change;
- Angela Rowe (Department of Atmospheric and Oceanic Sciences): remote sensing, cloud physics, weather process;
- Shanan Peters (Department of Geoscience): geoinformatics, geo-database, machine reading and learning, quantitative stratigraphy;
- Basil Tikoff (Department of Geoscience): tectonics, structural geology, geo-database, geology-related spatial cognition;
- Min Chen (Department of Forest and Wildlife Ecology): earth system science.

Thank You!

I look forward to discussing with you!

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The end