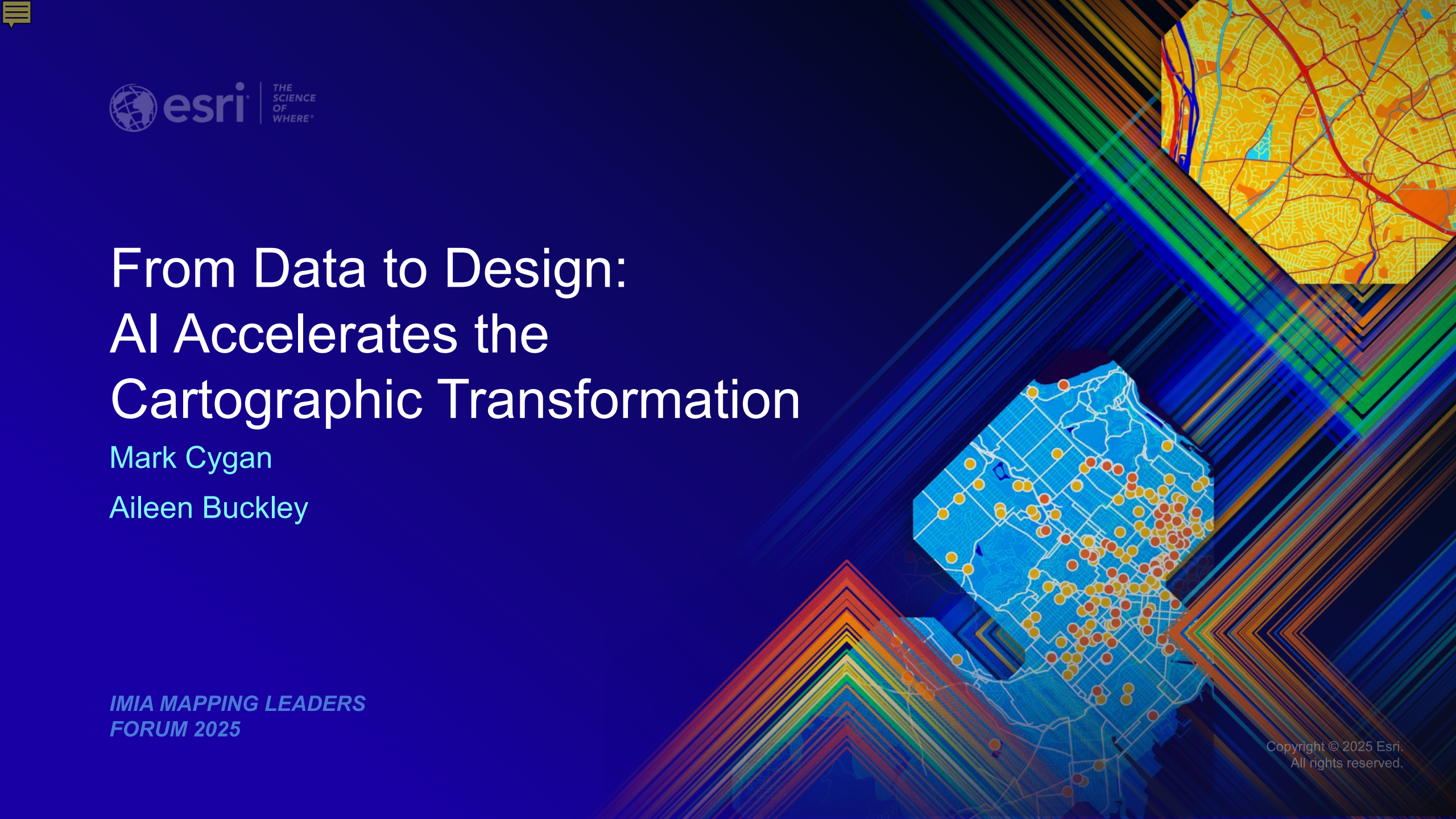
From Data to Design: AI Accelerates the Cartographic Transformation

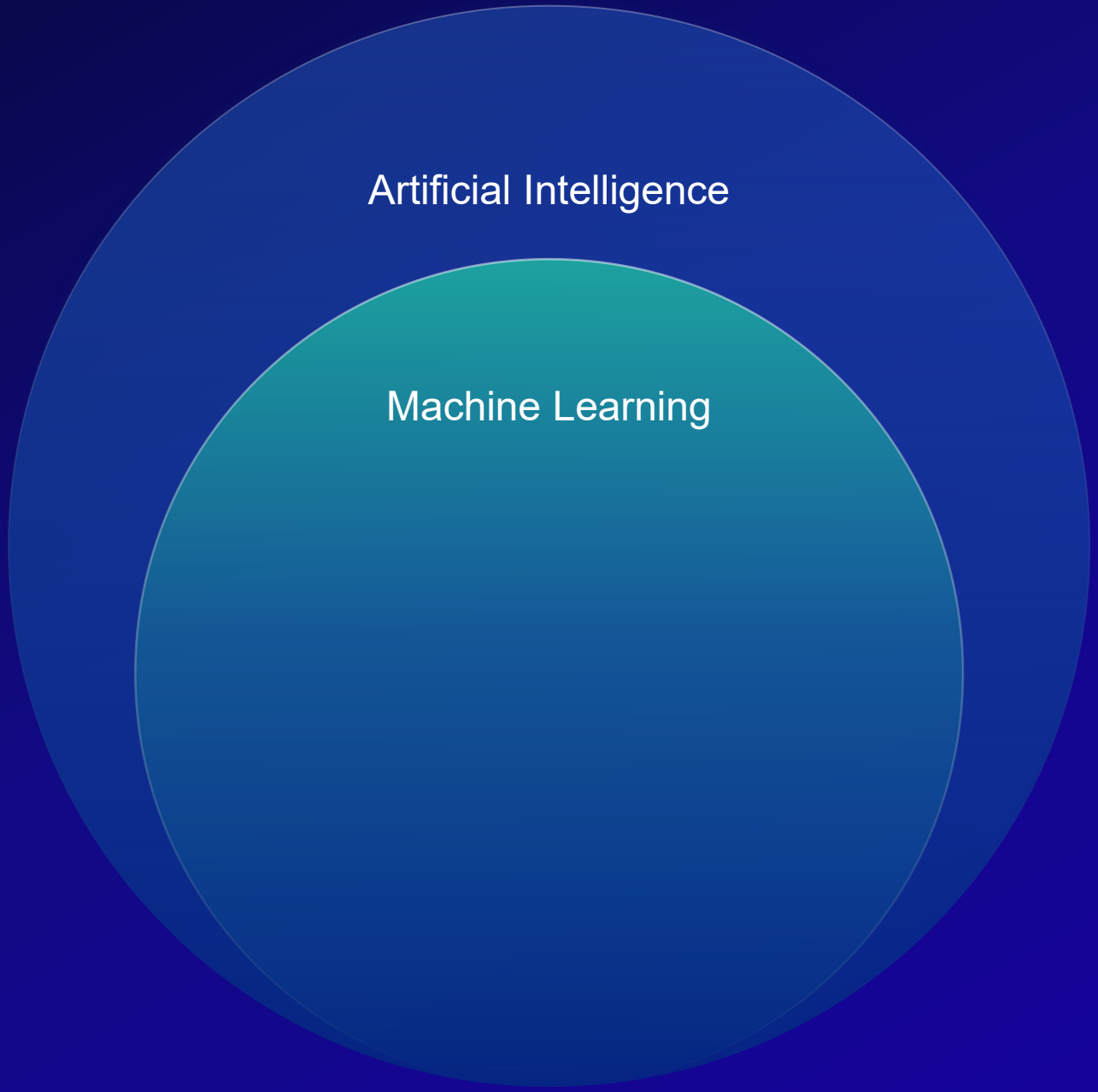
Mark Cygan

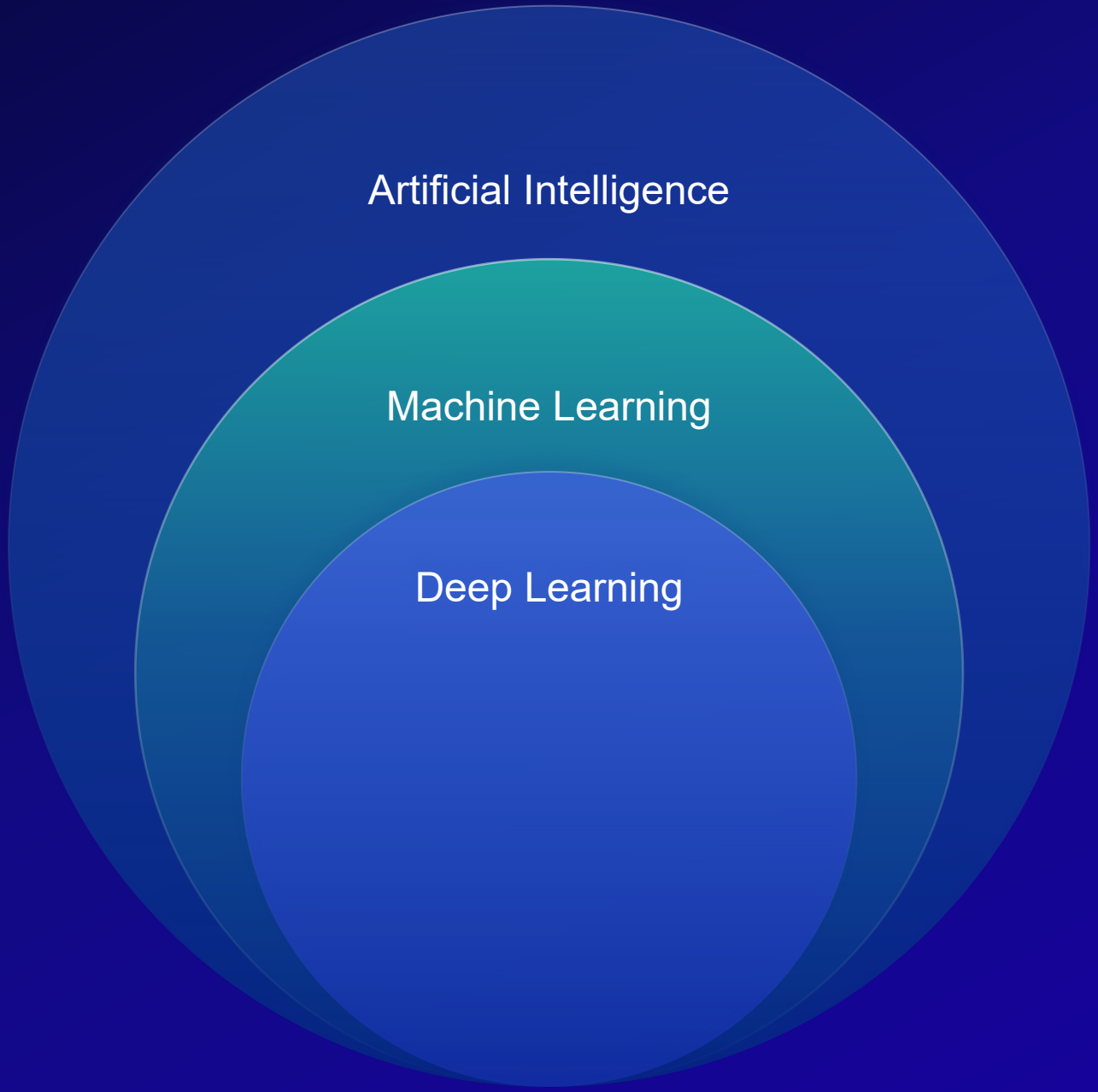
Aileen Buckley

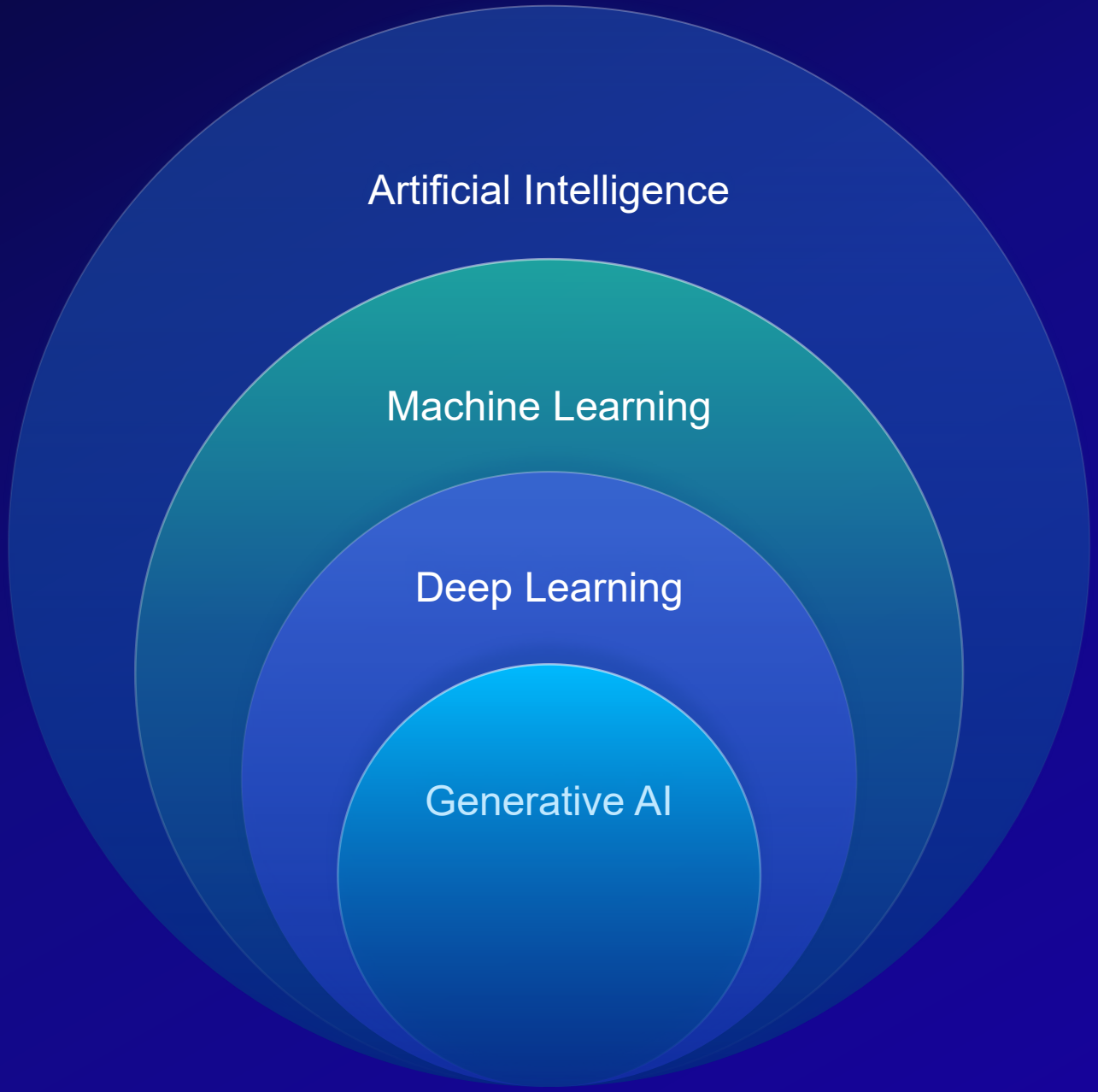


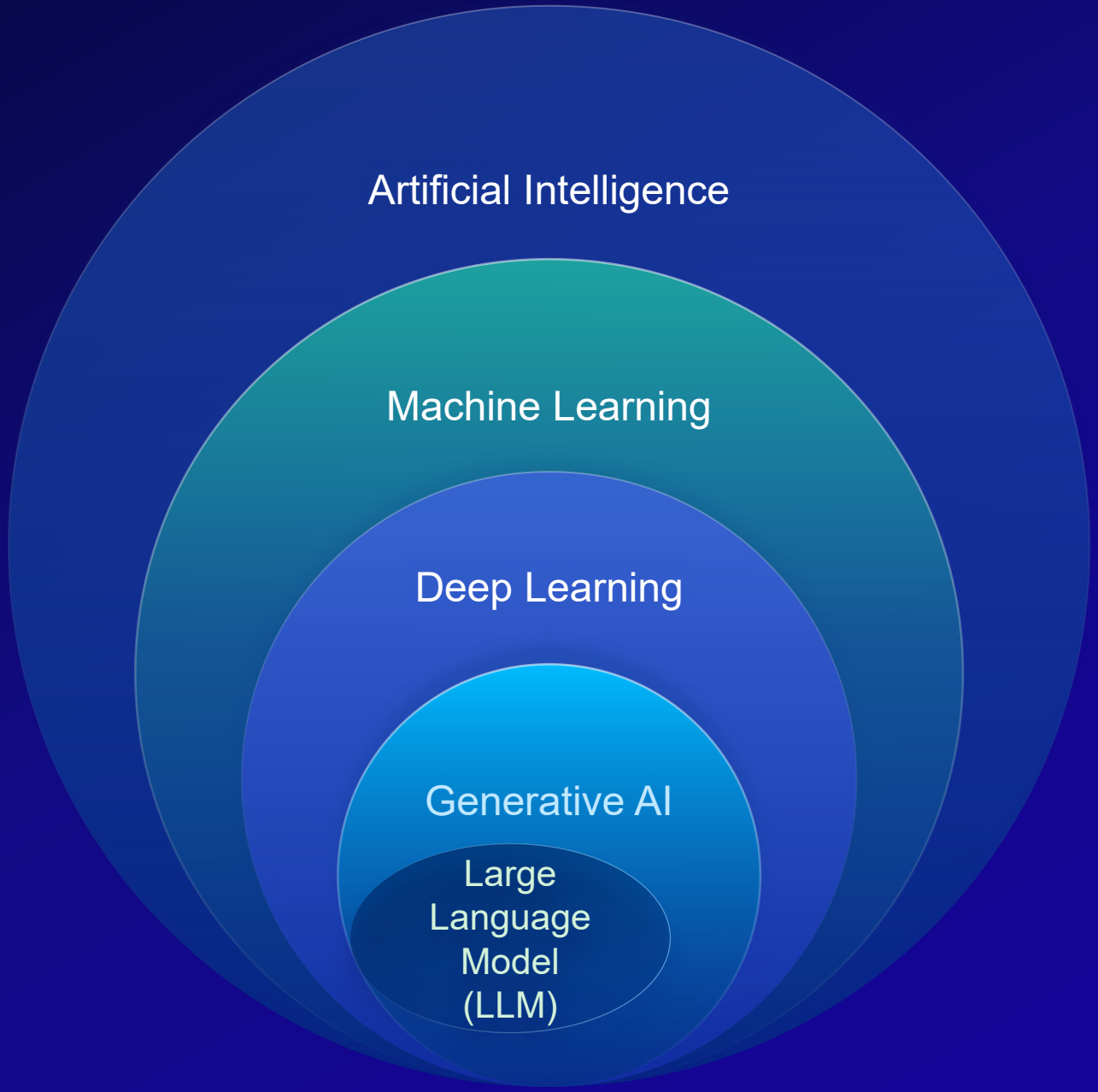
IMIA MAPPING LEADERS FORUM 2025

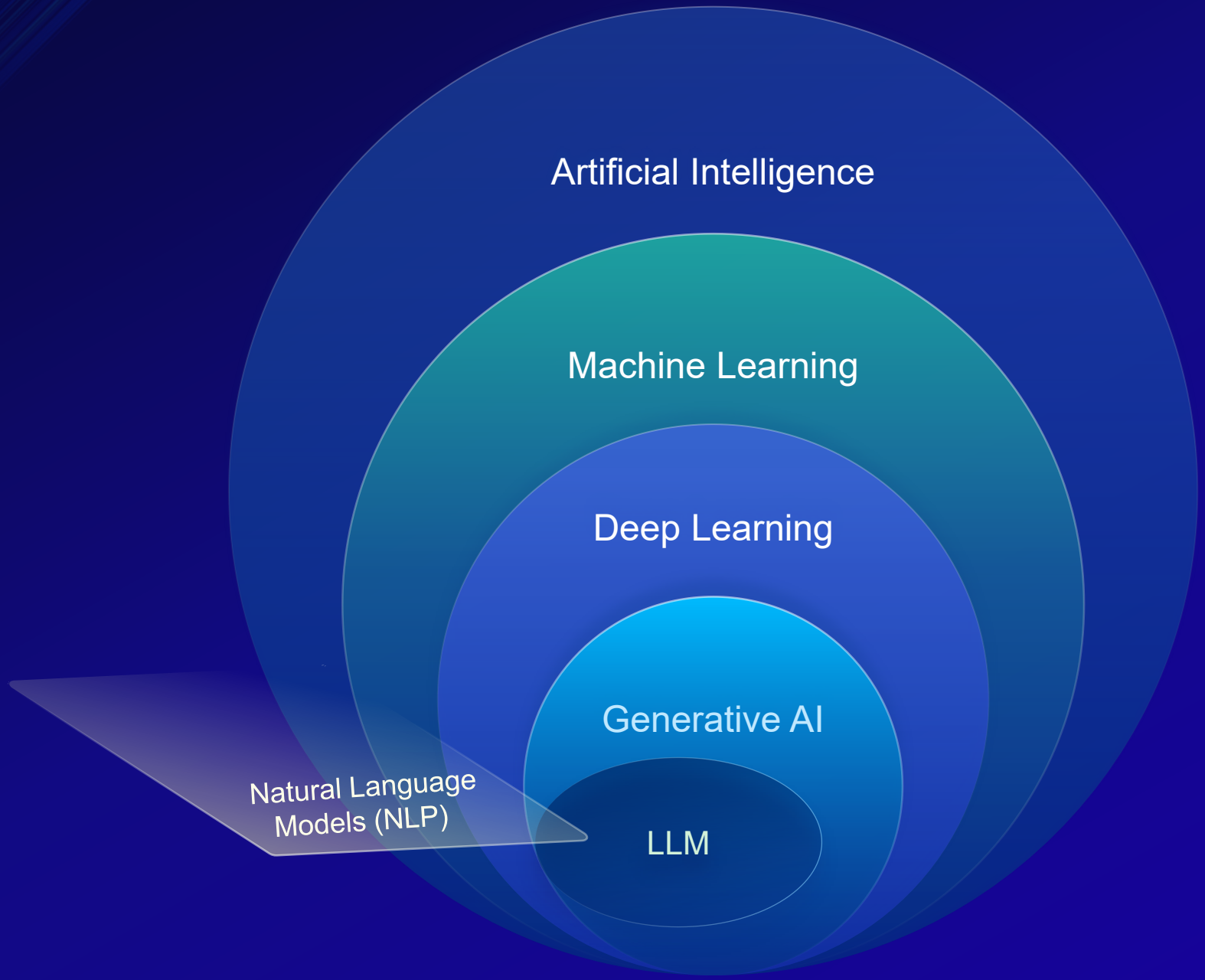
Artificial Intelligence

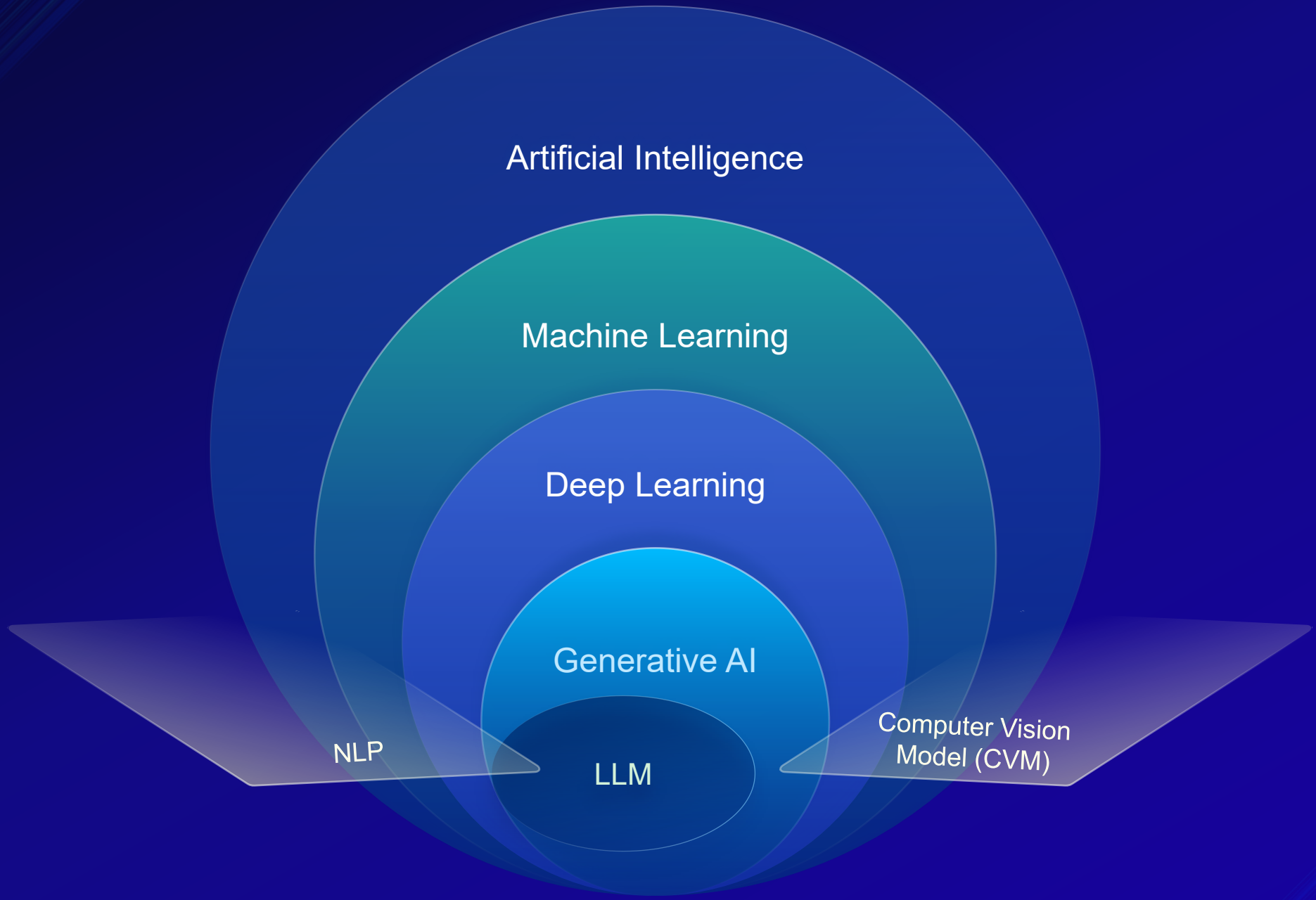

Artificial Intelligence
Machine Learning

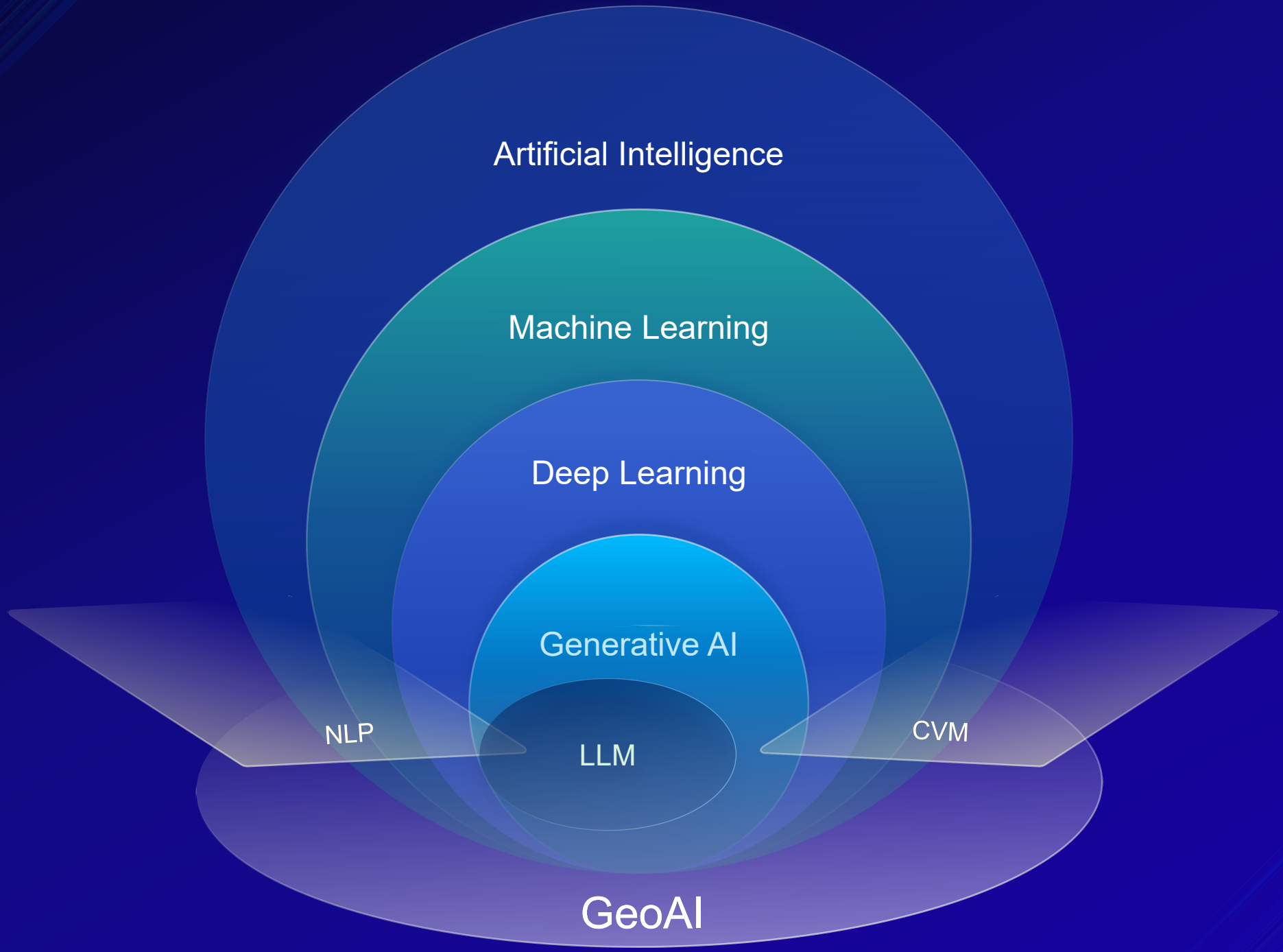

Artificial Intelligence
Machine Learning
Deep Learning

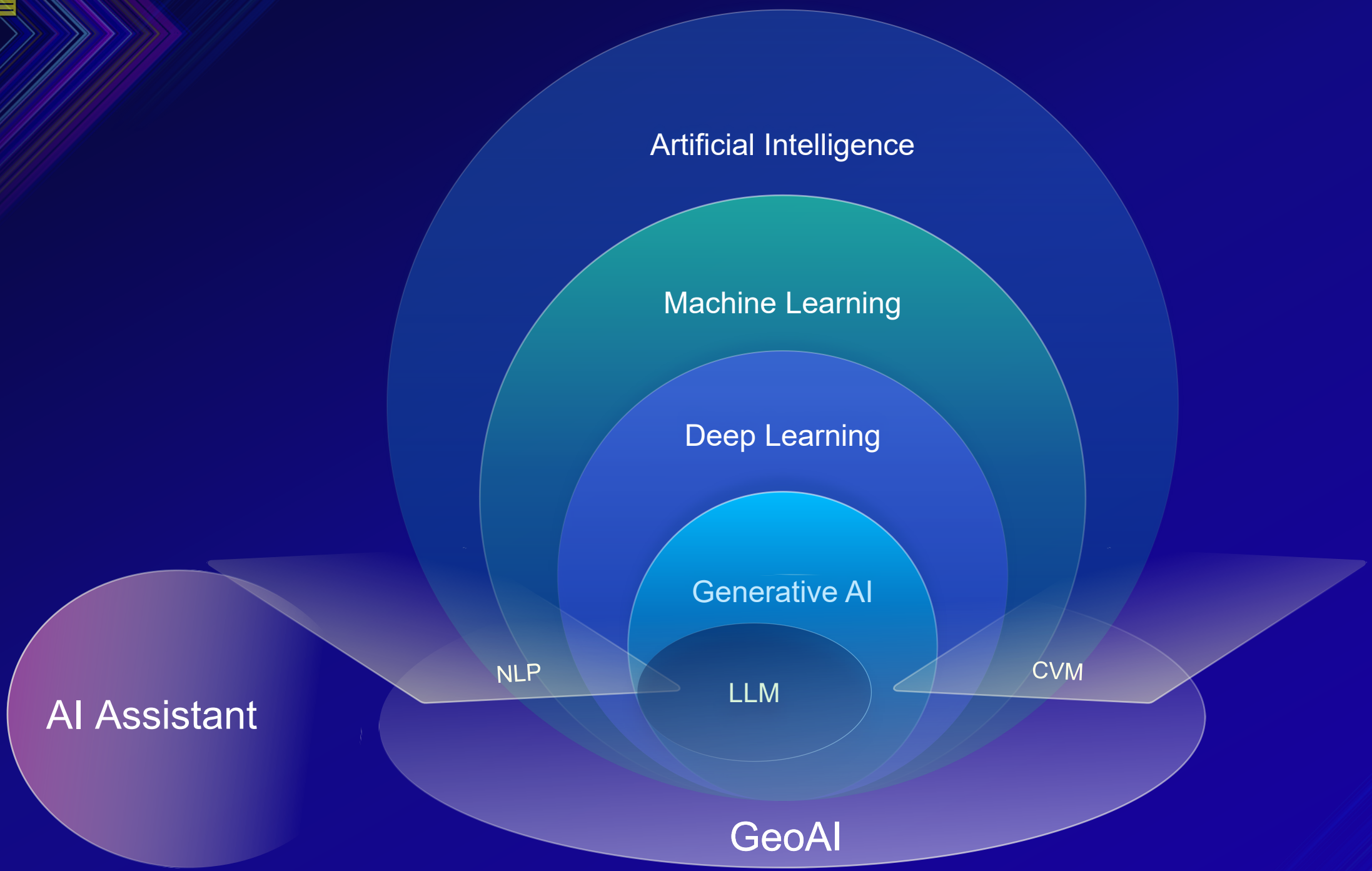

Artificial Intelligence
Machine Learning
Deep Learning
Generative AI


Artificial Intelligence
Machine Learning
Deep Learning
Generative AI
Large Language Model (LLM)

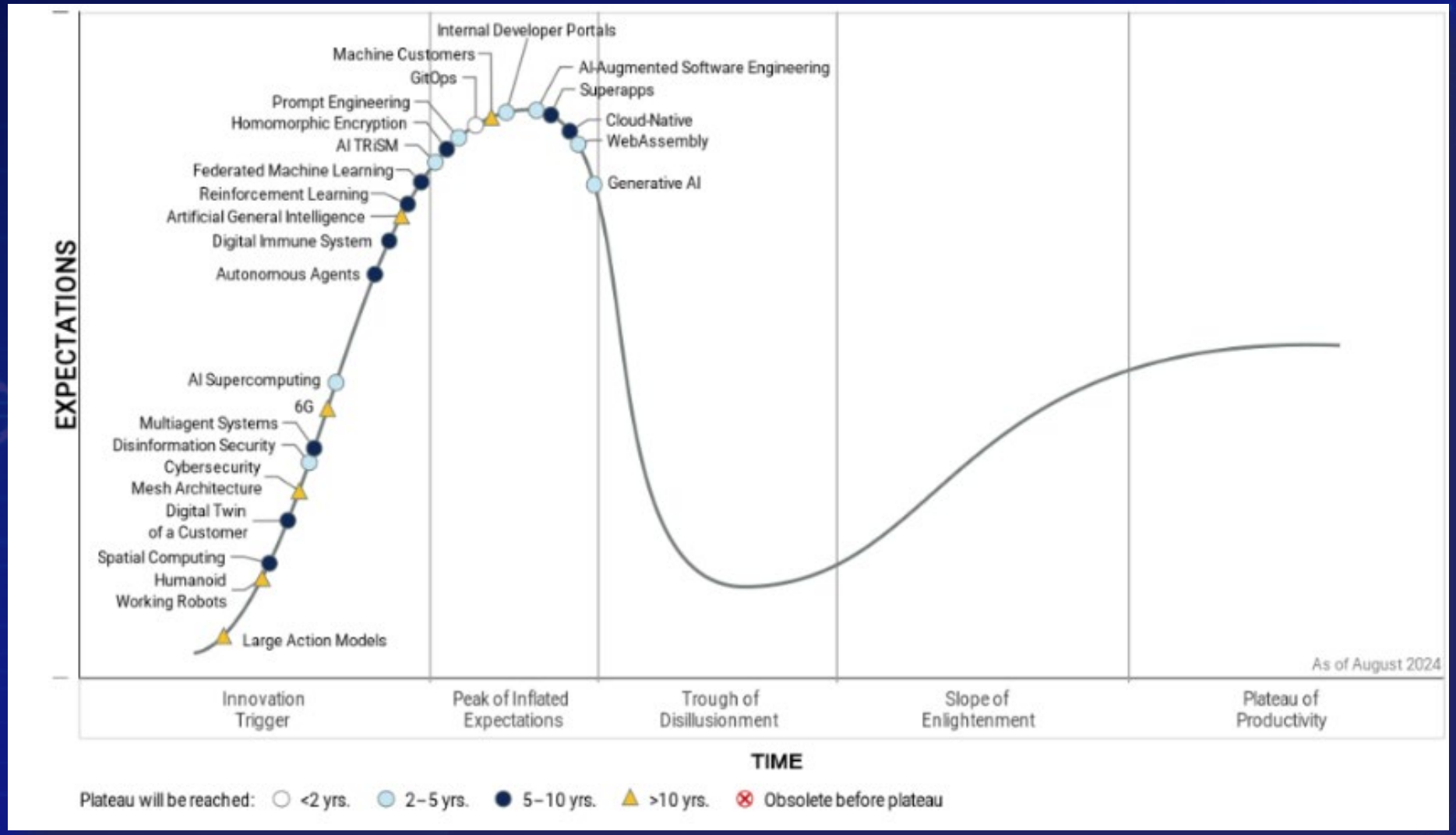

Artificial Intelligence
Machine Learning
Deep Learning
Generative AI
LLM
Natural Language
Models (NLP)


Artificial Intelligence
Machine Learning
Deep Learning
Generative AI
LLM
NLP
Computer Vision
Model (CVM)


Artificial Intelligence
Machine Learning
Deep Learning
Generative AI
LLM
NLP
CVM
GeoAI


Artificial Intelligence
Machine Learning
Deep Learning
Generative AI
LLM
NLP
CVM
AI Assistant
GeoAI

Why Should You Care About AI?



Gartner Hype Cycle for Emerging Technologies…, 21 August 2024

GIM INTERNATIONAL

Topics Articles News Case studies Members Events

ARTICLE

What is top of mind in today's geospatial sector?

Industry survey reveals ambitions, investment plans and visions for progress

By Wim van Wegen • February 26, 2025

Read our analysis of the results from the most recent 'GIM International' industry survey to discover fellow professionals' ambitions, investment plans and visions for progress.

Our industry survey has become an annual tradition, allowing us to assess the development of the geospatial sector. While there may appear to be little change year year, a broader perspective over a multiyear timespan reveals the technological and societal shifts shaping the industry's evolution. This report, based on analysis of *GIM International*'s 2025 geospatial industry survey, takes a step back to examine the longe term trends, providing a clearer view of where the industry is heading and giving insigh into mapping and surveying professionals' visions of the future.

Despite being indispensable across countless aspects of life and business, the geospa sector has long been overlooked – or at least underestimated – by the outside world. Li the engine beneath the bonnet of a car, geospatial data works in the background, crucially driving numerous processes yet barely noticed. But the geospatial sector's technical ingenuity is no longer entirely hidden. As data capturing solutions have advanced and matured over the past years, geospatial data has become more affordab reaching a wider user group as a result and playing a valuable part in the broader trenc known as Industry 4.0 (and, increasingly, Industry 5.0).

AI is a game changer

Needless to say, there's no avoiding AI when asked about the development with the most impact on the industry. As one geospatial professional shares: "Artificial intelligence, particularly in the realm of deep learning, has had a profound impact on remote sensing, influencing multiple facets such as data acquisition, processing, analysis and interpretation." According to this expert, the integration of AI into remote sensing significantly enhances data quality, automates data processing, refines feature extraction and classification, facilitates change detection, enables data fusion, and streamlines quality control procedures. These advancements will lead to more accurate, comprehensive and timely analysis and interpretation of remote sensing data.

"By employing AI methods like deep learning, professionals in the field can not only improve the quality of the data they work with, but also extract meaningful insights and automate numerous aspects of data analysis. This approach unlocks the full potential of remote sensing technology for a wide range of applications," the respondent continues.

In fact, the continued integration of AI, machine learning, and real-time analytics into geospatial workflows leads the pack of emerging trends and technologies that will shape the geospatial industry most significantly in the coming years, with no less than 80% of respondents in agreement on this. The high degree of consensus underscores the industry's strong belief in the transformative potential of these technologies to enhance decision-making, efficiency and automation in geospatial applications.

International 2025 Geospatial Industry Survey, 26 February 2025 article, "What is top of mind in today's geospatial sector?"

What Are the Challenges with AI?

Technical Challenges

- Hallucinations
- Garbage in, garbage out
- Computing resources
- Open vs Closed –
- chatGPT vs <YourCompany>ChatGPT
- and more…

Social Challenges

- Will AI take my job?
- Human in the loop
- Intellectual Property (IP) violations
- Derivative products
- Privacy concerns
- Environmental impacts
- and more…

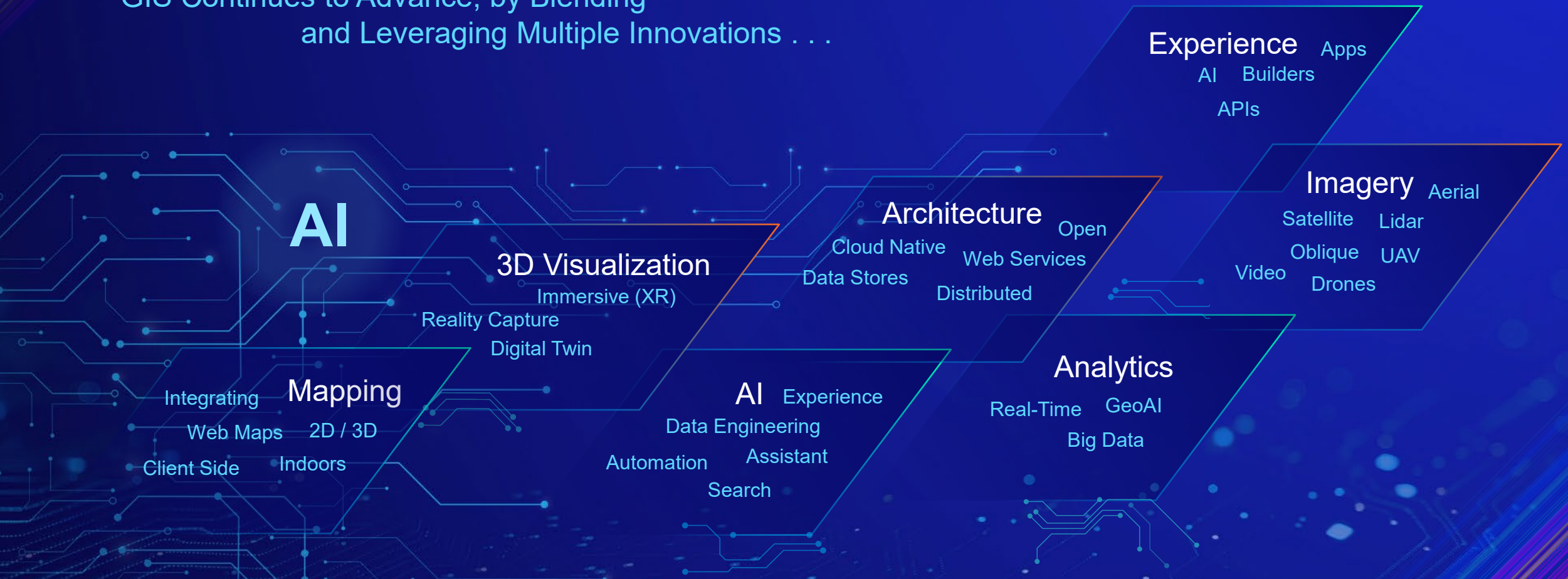
Esri’s AI Assistants

Accelerate intelligent decision-making, assist
in providing actionable recommendations,
create effective information products…
improve user productivity and efficiency,
deliver meaningful and relevant
geospatial insights derived from data.

. . . Empowering You with Deeper Intelligence and Enabling Automation at Scale

AI in Our Context

GIS Continues to Advance, by Blending and Leveraging Multiple Innovations . . .



. . . AI is Helping Us to Redefine and Transform the Role and Impact of GIS

Esri's Motivations to Infuse ArcGIS with AI . . .

To help you with . . .

- Enhanced Productivity
- Accelerated Decision Making
  (Days > Hours > Minutes)

Esri's Motivations to Infuse ArcGIS with AI . . .

To help you with . . .

- Enhanced Productivity
- Accelerated Decision Making
  (Days > Hours > Minutes)

By providing tools for . . .

- Automated Data Creation / Extraction and Processing
- Advanced Spatial Analysis and Visualization
- Predictive Analytics and Forecasting
- Real-Time Data Integration and Processing

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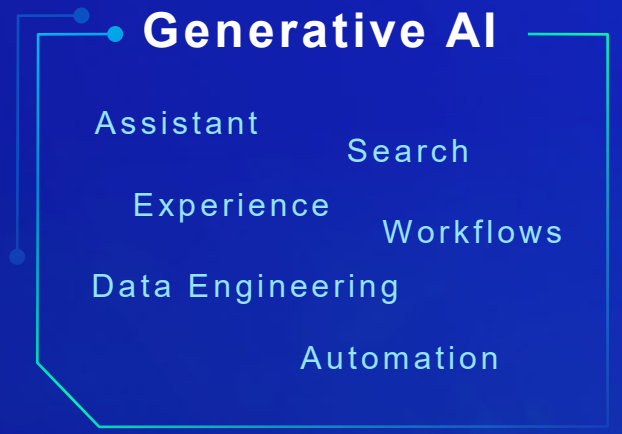

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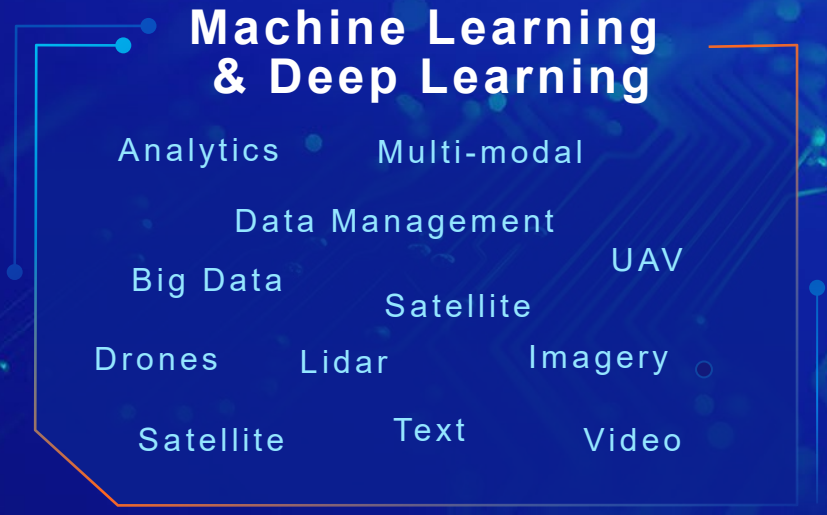


. . . Deliver Answers and Geospatial Insights Derived From Data

AI in ArcGIS

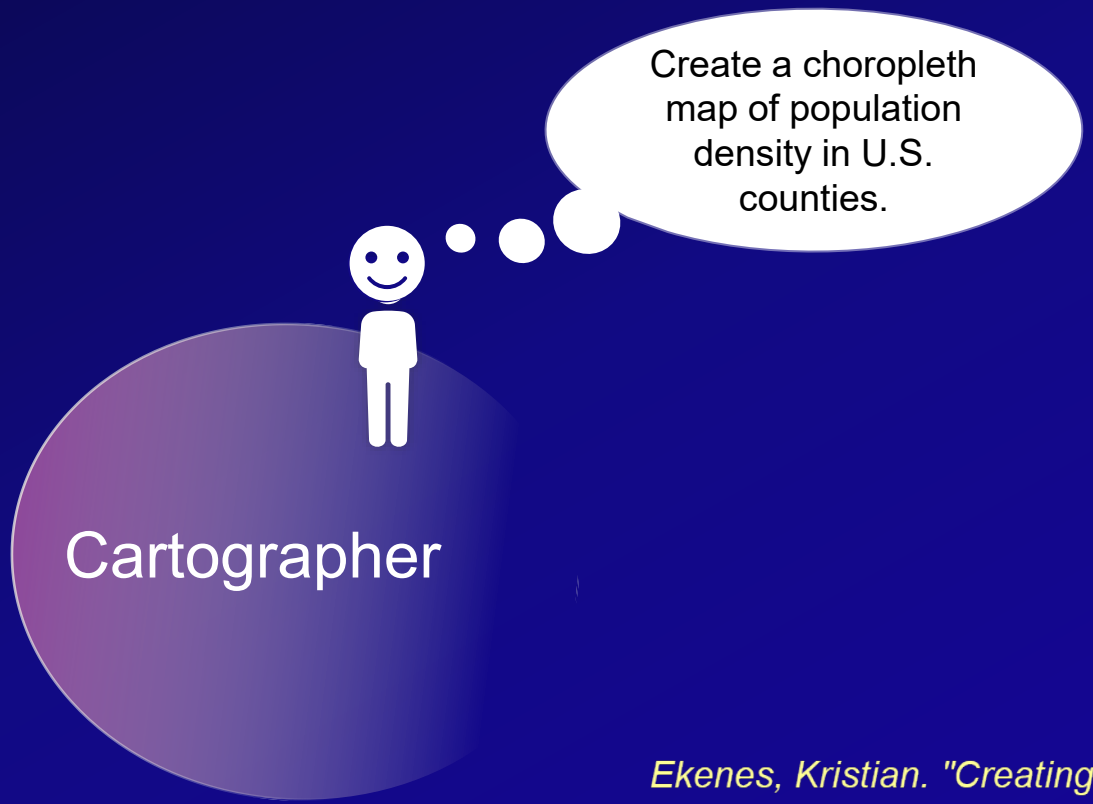
GeoAI for Science

Advancing the ***Science of GIS***, with AI models, tools and techniques, to automate data extraction at scale and uncover valuable insights faster than ever.

GeoAI for ArcGIS Use

Creating more natural and intuitive ***Experiences with ArcGIS***, using intelligent *AI assistants and agents*, to empower GIS users and boost productivity.

Cartography with AI Today



Ekenes, Kristian. "Creating Thematic Maps with the Help of Generative AI". NACIS Annual Meeting, 2024.

Cartography with AI Today

Create a choropleth map of population density in U.S. counties.

Cartographer

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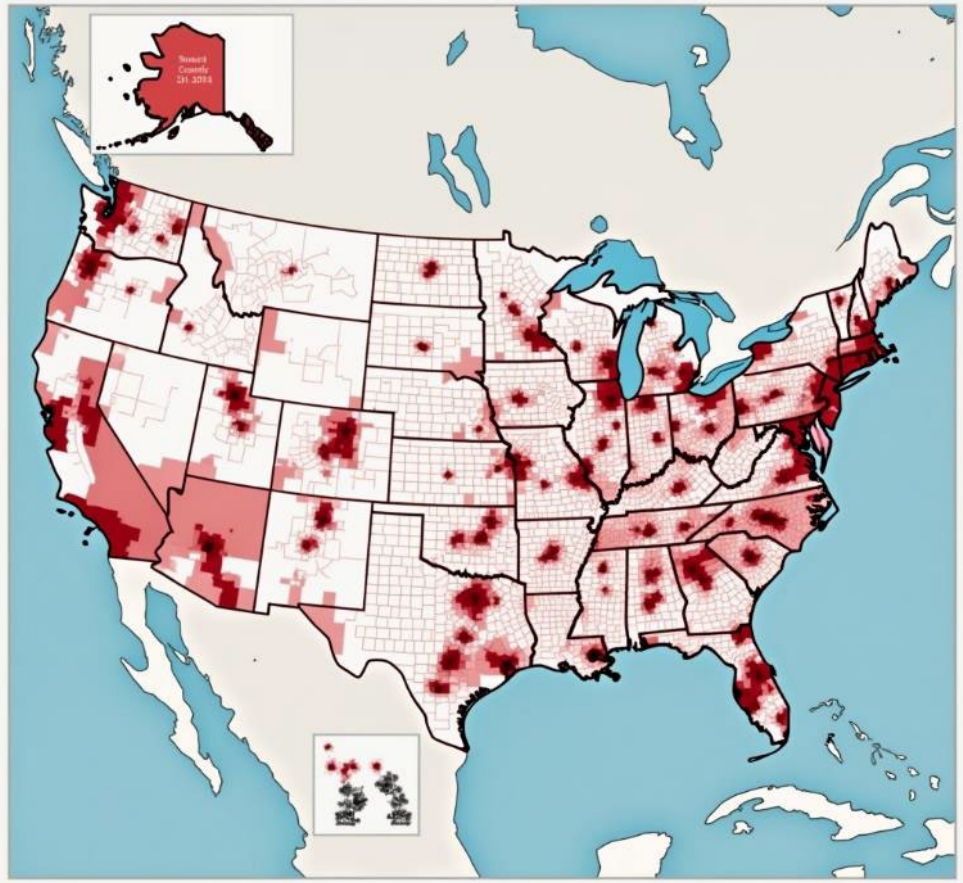

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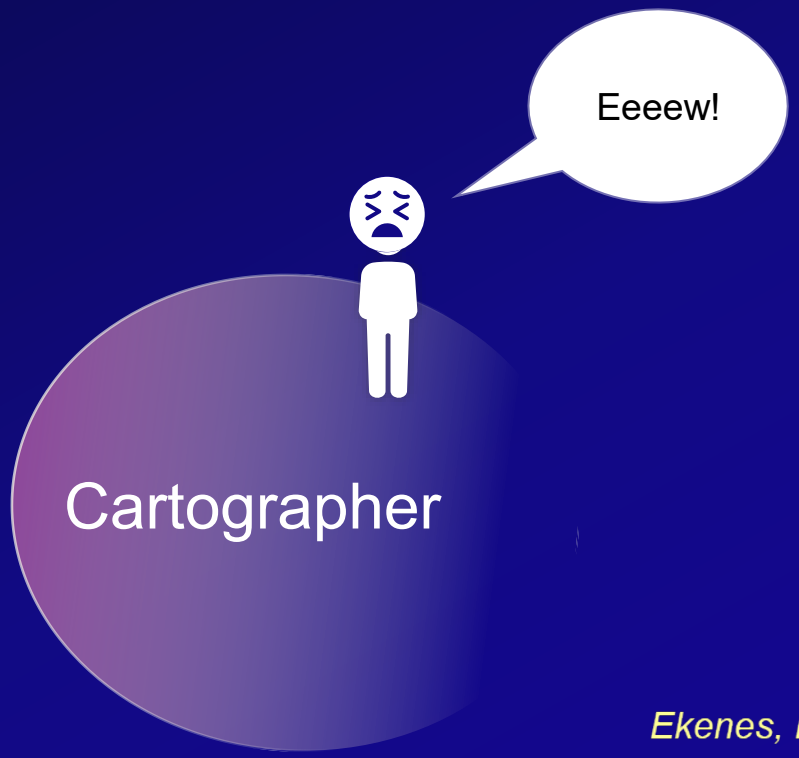

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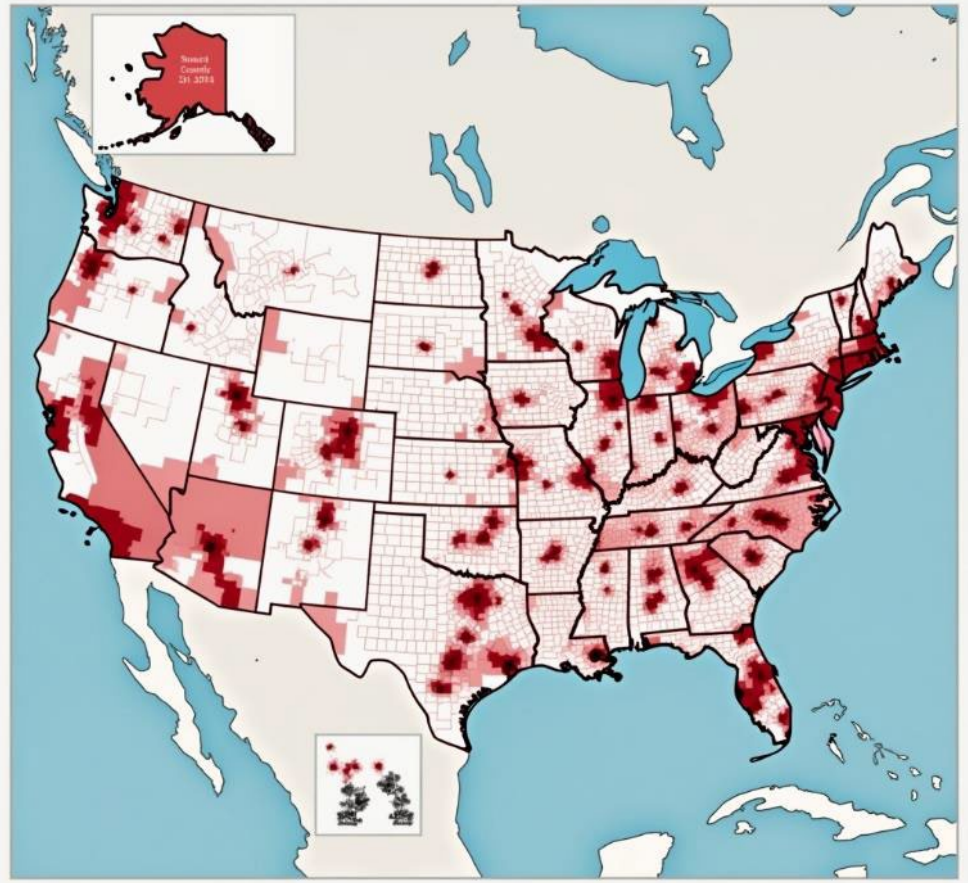

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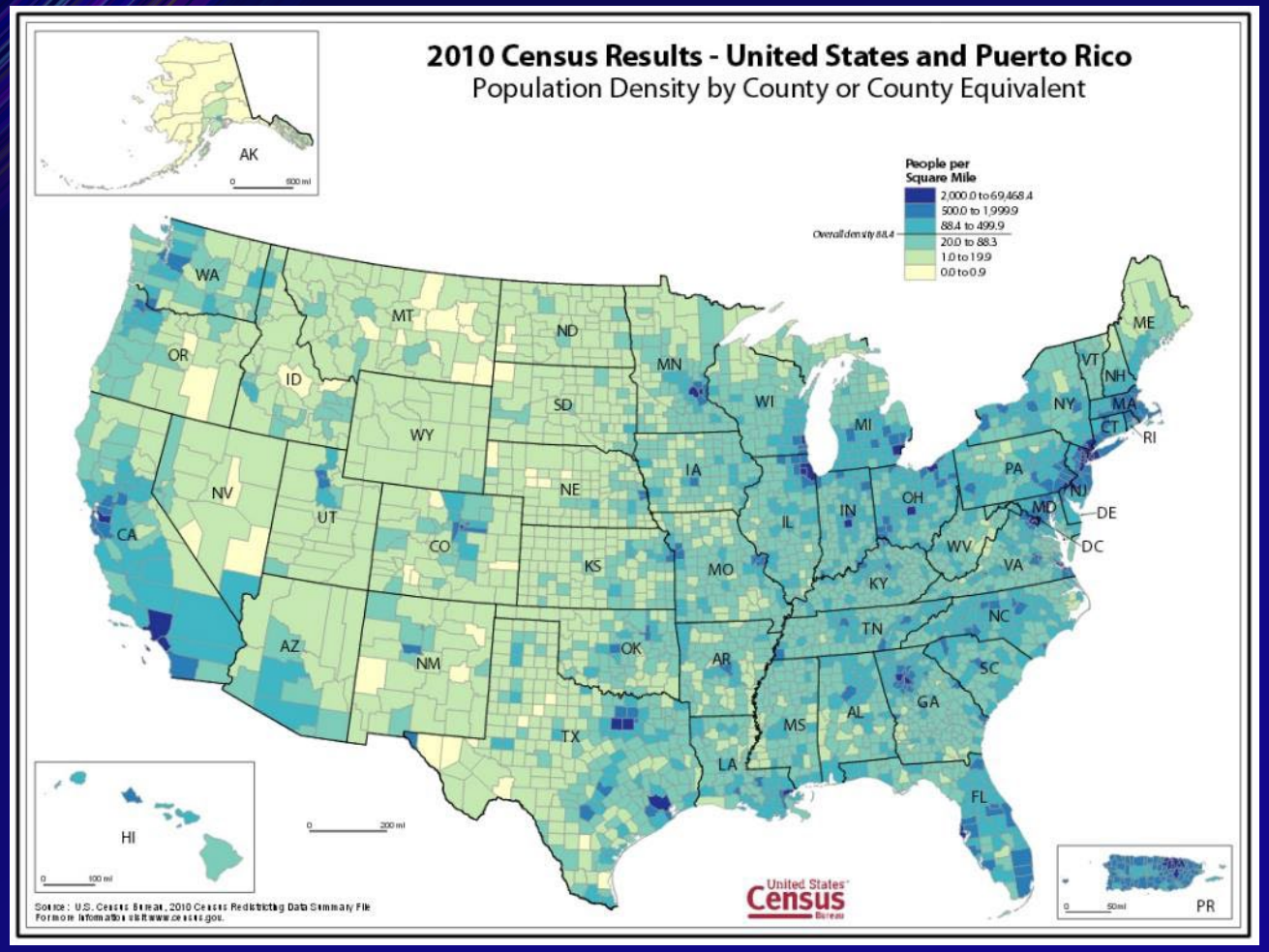
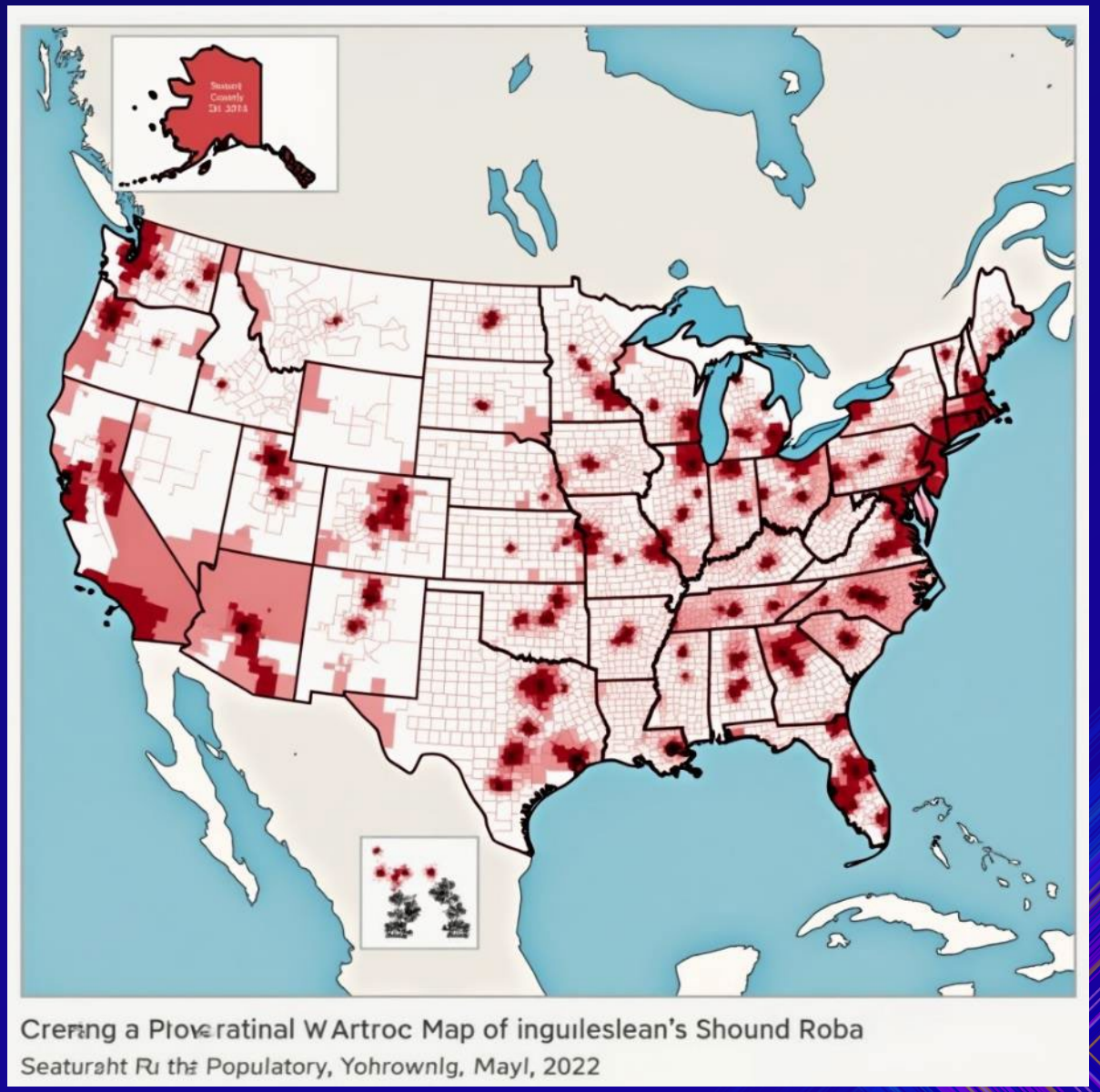


Created by U.S. Census Bureau



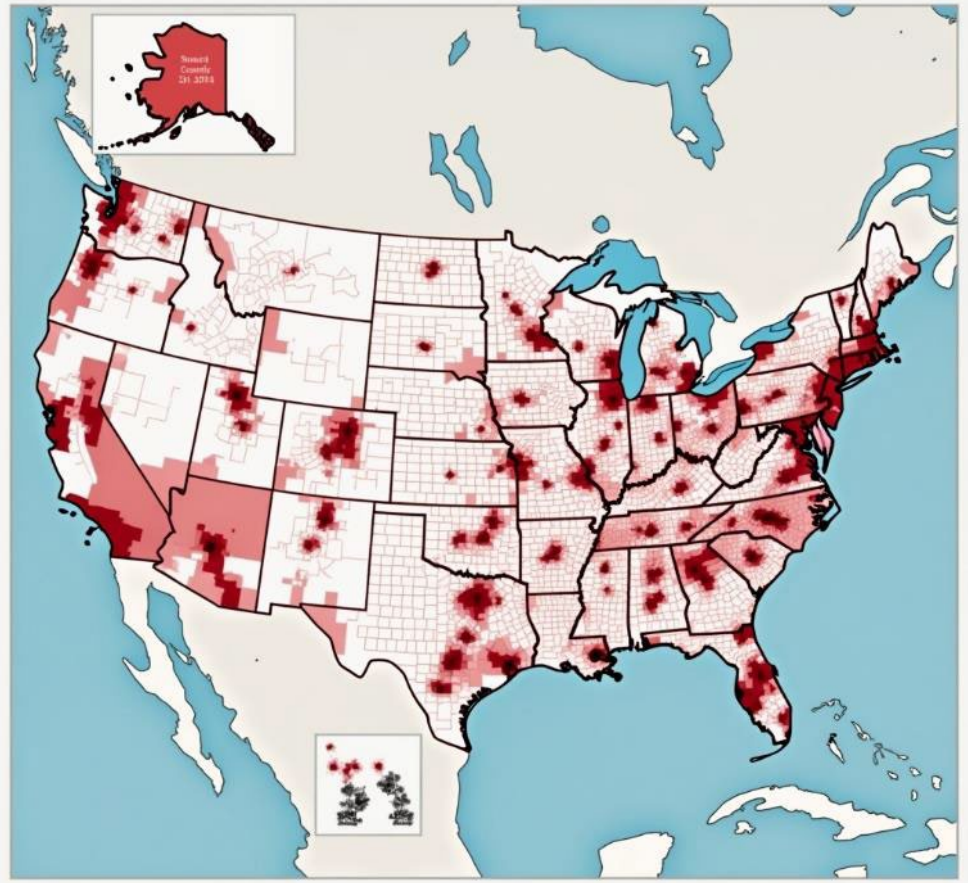
Created by OpenArt AI

Cartography with AI Today

Why are the results so bad?

Cartographer

Create a choropleth map of population density in U.S. counties.



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Cartography with AI Today

Poor results

- AI is not designed as mapmaking software
- High degree of variability
- Reproducibility is difficult
- Results can't easily be modified

Cartographer

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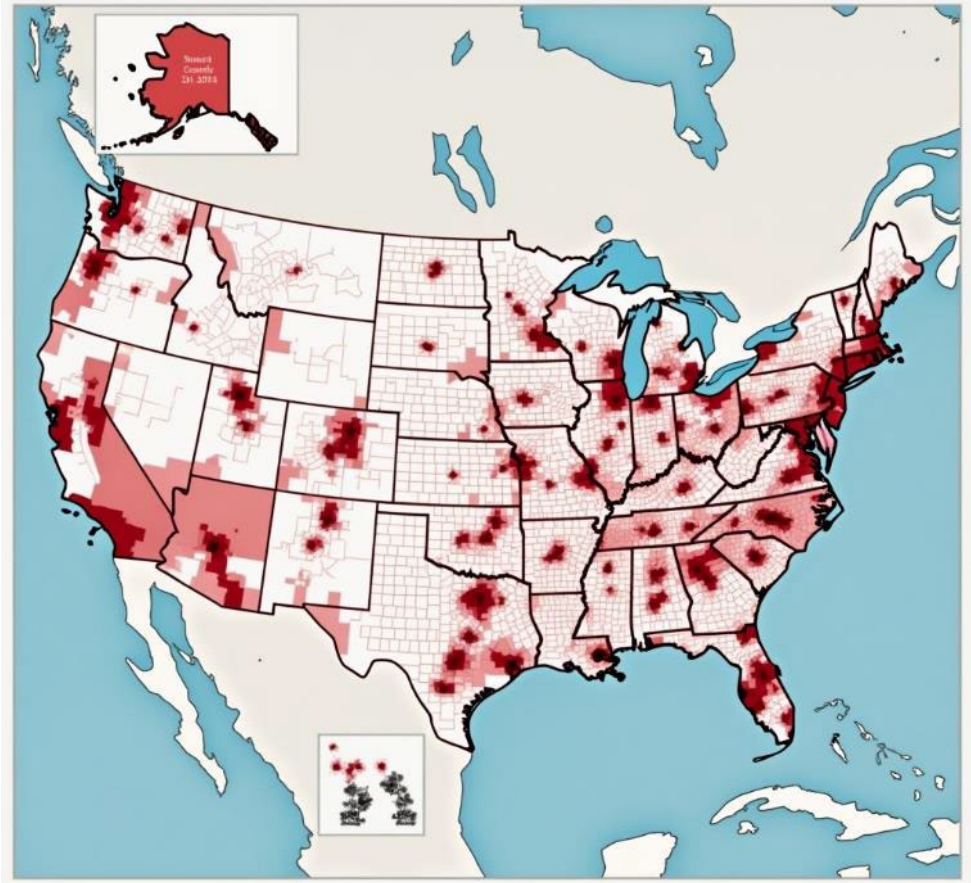

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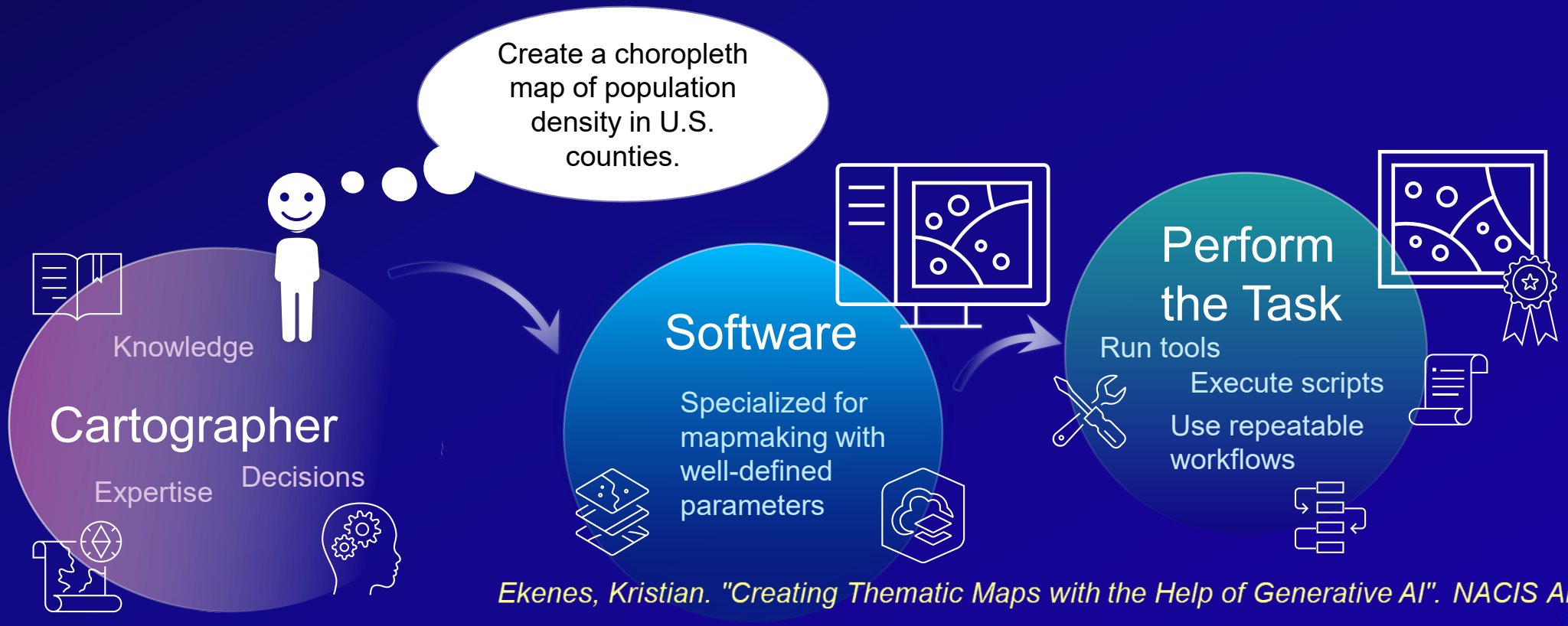
Cartography without AI

The Cartographer expresses their intent through the GUI.
The Cartographer uses specialized software to create the map.



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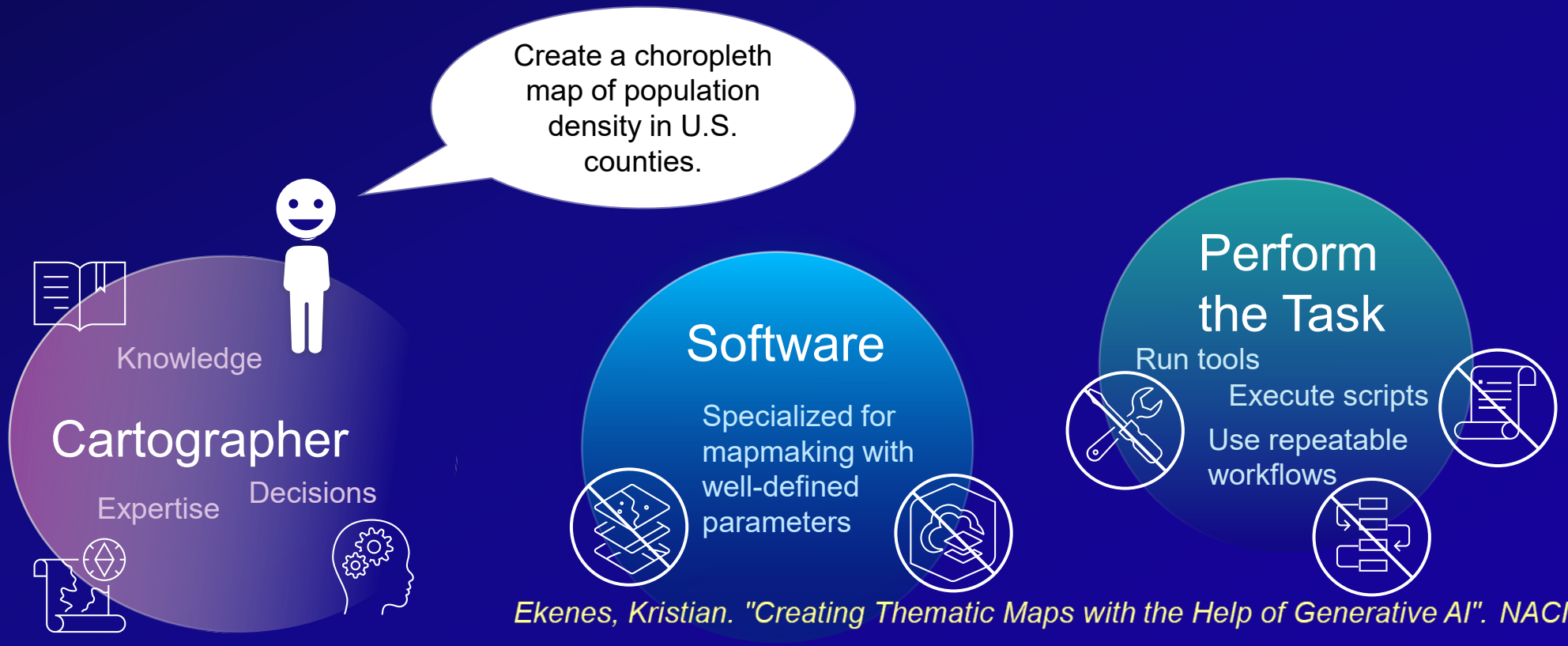
Cartography with AI

The Cartographer expresses their intent through natural language.



Ekenes, Kristian. "Creating Thematic Maps with the Help of Generative AI". NACIS Annual Meeting, 2024.

Cartography with AI

The Cartographer expresses their intent through natural language.
The LLM determines the intent and creates the map.

Natural Language User Interface

Proportional symbols

Population

U.S. counties

Large Language Model

Translate

Create

AI knowledge

Create a choropleth map of population density in U.S. counties.

Knowledge

Cartographer

Expertise

Decisions

Software

Specialized for mapmaking with well-defined parameters

Perform the Task

Run tools

Execute scripts

Use repeatable workflows

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Poor results

- AI's cartographic knowledge isn't trustworthy
- Permission / copyright concerns arise

Natural Language User Interface

Proportional symbols

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Cartography with AI in ArcGIS

The Cartographer expresses their intent through the GUI with natural language.
The LLM determines the intent and returns the parameters.

API parameters in JSON

```
{
  method: "create",
  style: "proportional symbol",
  field: "B08301_015E",
  colors: "blue 1"
}
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Large Language Model

Translate

Create

AI knowledge

Natural Language User Interface

Proportional symbols

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Large Language Model

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Whew!

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Cartography with AI

The Cartographer expresses their intent through the GUI with natural language.
The LLM determines the intent and returns the parameters.
The Cartographer finishes the map.

API parameters in JSON

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Natural Language User Interface

Proportional symbols

Population

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Large Language Model

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AI knowledge

Perform the Task

Create a style

Provide options for modification

Software

Specialized for mapmaking with well-defined parameters

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API parameters in JSON

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  field: "B08301_015E",
  colors: "blue 1"
}
```

Good results

- The Cartographer's knowledge is used
- The Cartographer knows the software
- No permission / copyright concerns

Natural Language User Interface

Proportional symbols

Population

U.S. counties

Large Language Model

Translate

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Esri’s Approach to Creating a Map with Generative AI

- An LLM’s knowledge of cartography cannot be trusted without human validation.
- A human must always be part of the map-making process.
- Generative AI may be used in the map making process to:
  - Increase accessibility,
  - Improve efficiency
  - Inspire creativity, and
  - Discover alternate ways of visualizing data.
- Integrate the assistant within the specialized software, but never replace the GUI so that the generated content can be modified and finished by the cartographer (thru NLUI + GUI).
- The Cartographer must always have the final say in the visualization.
- Capabilities, audiences, and use cases will evolve and expand over time.

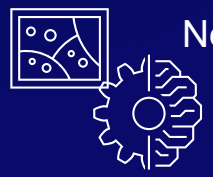
Ekenes, Kristian. "Creating Thematic Maps with the Help of Generative AI". NACIS Annual Meeting, 2024.

Potential Uses of the Mapping Assistant

Who needs help and what do they need help with?

Personas

Lay person



Needs a map but can't make one
Doesn't know the terminology
Unfamiliar with the software

GIS professional

Cartographers and mapmakers
Experienced with GIS software
Understands technical terms

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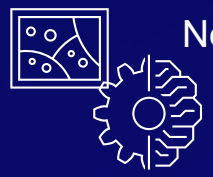


Needs a map but can't make one
Doesn't know the terminology
Unfamiliar with the software

"color"
"amount"

GIS professional

Cartographers and mapmakers
Experienced with GIS software
Understands technical terms

"choropleth"
"population density"

Workflows

Suggestions or Ideas

Unknown goal
Simple terms
Unknown data
Unknown style
Few details

The Assistant offers suggestions, gives you ideas, and allows you to try different styles

Adjustments or Modifications

Specific adjustments
Mostly finished map
Known options
Minor modifications

The Assistant exposes the GUI to let you make the adjustments or modifications you want

Clear Goal or Map Style

Technical terms
Specific data
Specific style
Technical details

The Assistant attempts to complete the map by doing what you ask it to do

Ekenes, Kristian. "Creating Thematic Maps with the Help of Generative AI". NACIS Annual Meeting, 2024.

Thoughts and Observations

Based on User Studies

- The generated map is never finished.
- Although LLMs be the interface for making the map (at least the first version), the software must be able to permit the Cartographer to make the final design decisions.
- The Cartographer should be in control and is therefore responsible and accountable for what they create.

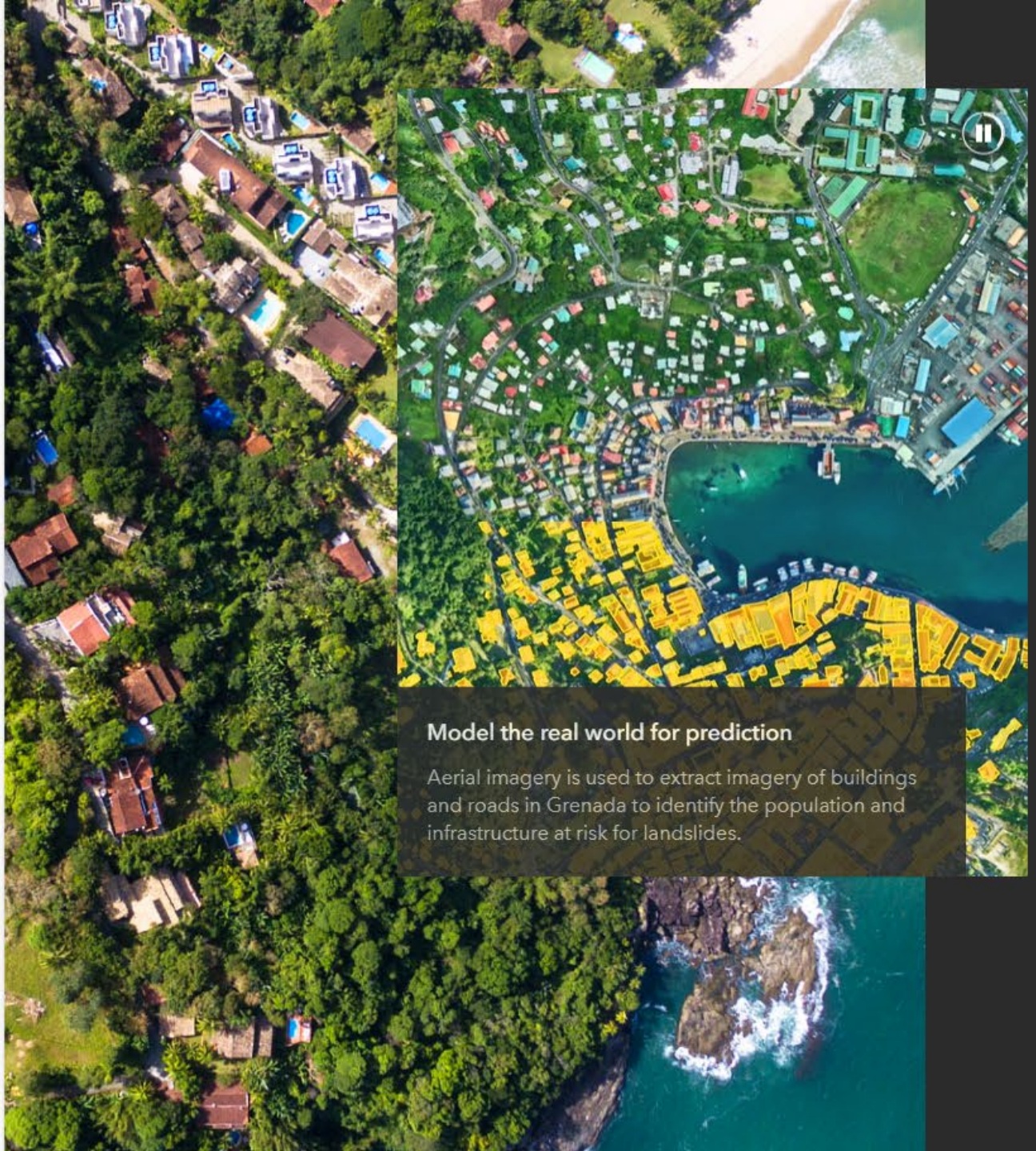
Additional Resources

1. GeoAI page - https://www.esri.com/en-us/capabilities/geoai/overview

GeoAI

AI-driven geospatial workflows

Discover how organizations are building a more resilient future with accelerated spatial problem-solving



Model the real world for prediction

Aerial imagery is used to extract imagery of buildings and roads in Grenada to identify the population and infrastructure at risk for landslides.

Definition

What is GeoAI?

Geospatial artificial intelligence (GeoAI) is the application of artificial intelligence (AI) fused with geospatial data, science, and technology to accelerate real-world understanding of business opportunities, environmental impacts, and operational risks. Organizations are modernizing operations to run at scale through automated data generation and approachable spatial tools and algorithms.

1. **Extract rich geospatial data with deep learning**

   Save time by automating the extraction, classification, and detection of information from data such as imagery, video, point clouds, and text.

2. **Perform predictive analysis using machine learning**

   Build more accurate models. Detect clusters, calculate change, find patterns, and forecast outcomes with spatial algorithms backed by experts.

Value

Why is GeoAI important?

GeoAI is transforming the speed at which we extract meaning from complex datasets, thereby aiding us in addressing the earth's most pressing challenges. It reveals and helps us perceive intricate patterns and relationships in a variety of data that continues to grow exponentially. Organizations leveraging GeoAI are revolutionizing how they turn data into information, with models that adapt even as data evolves.

1. **Improve data quality, consistency, and accuracy**

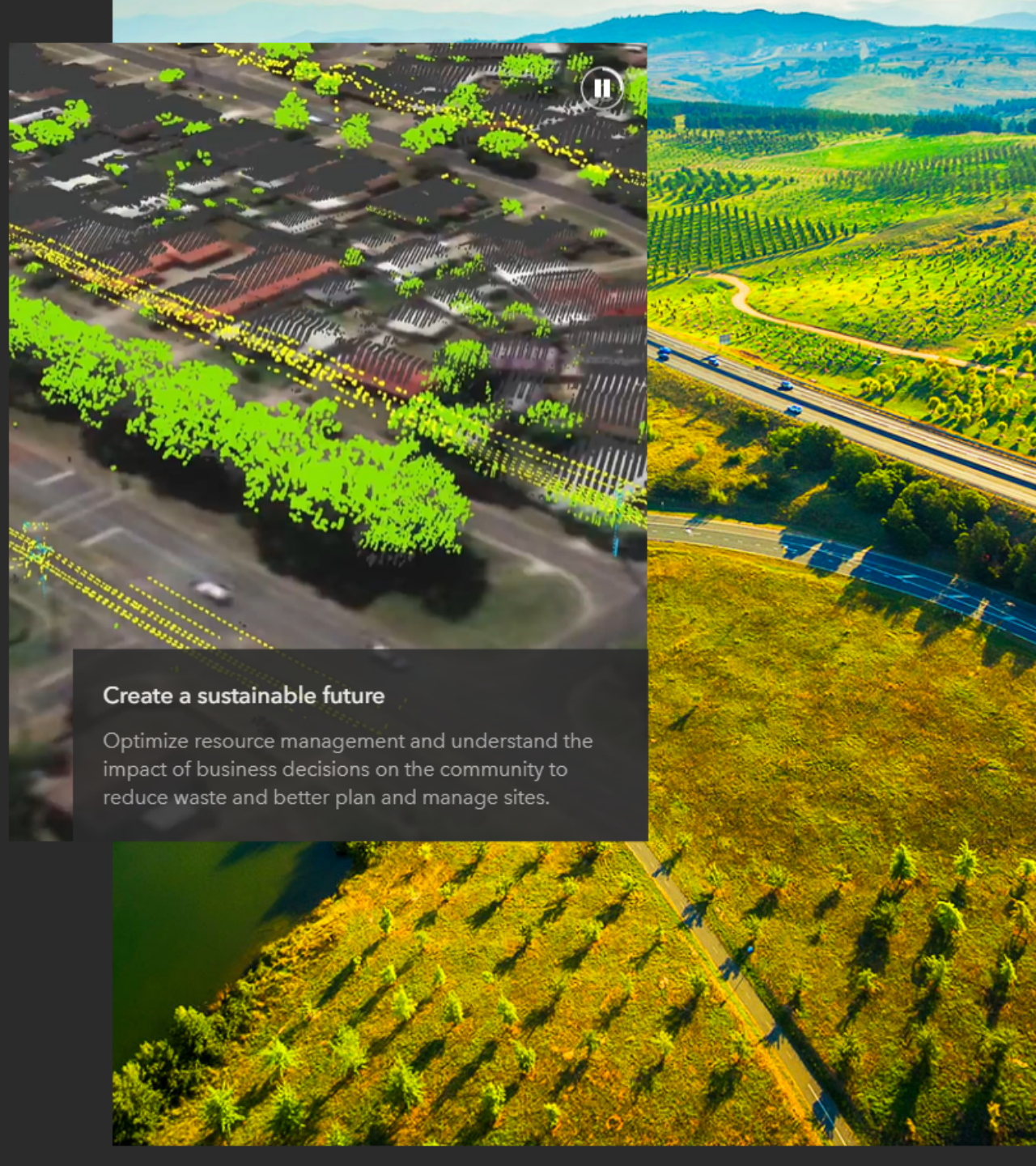
   Streamline manual data generation workflows by using the power of automation to increase efficiency and reduce costs.

2. **Accelerate the time to situational awareness**

   Monitor and analyze events, assets, and entities from sensors and sources such as video to enable quicker response times and proactive decisions.

3. **Bring location intelligence to decision-making**

   Make data-driven decisions with real-world awareness. Improve business outcomes with insight from spatial patterns and accurate predictions.



Create a sustainable future

Optimize resource management and understand the impact of business decisions on the community to reduce waste and better plan and manage sites.

How is GeoAI used?

GeoAI is used in various industries and applications to tackle challenges and proactively seize opportunities. Explore how GeoAI is used to optimize crop yields, heighten community safety, streamline asset inspection, shorten emergency response times, and more.

State and local government

GeoAI is accelerating the speed at which government officials better serve communities using data. By leveraging GeoAI, governments can model the impacts of urban development, understand the availability of resources to the population, forecast road and infrastructure deterioration, and identify land-use change (such as new buildings) to proactively take action.

Natural resources

GeoAI is revolutionizing the precision agriculture market by aiding the automated detection of invasive species. It helps the oil and gas industry monitor assets through automated extraction of flares, new well pads, or field access roads. Foresters and landowners use GeoAI to give them knowledge about the volumes and species of trees without a time-consuming on-site inspection.

National mapping and statistics

GeoAI is enhancing the responsiveness, productivity, and speed of product delivery for national mapping agencies. Through automation, these organizations are scaling their internal capacities and production workflows. A national mapping department can quickly update a nation's geographic information system (GIS) in hours, not months or days.

Defense and intelligence

GeoAI is speeding up how organizations extract information, identify patterns, and determine changes in big data. An intelligence organization can support its activity-based intelligence efforts by automating how they analyze information related to events, entities, surveillance video, and remotely sensed data.

Public safety

GeoAI is improving public safety as it relates to traffic accidents, emergency response, and disaster management. Organizations are making communities safer by predicting where accidents are likely to occur and optimizing emergency response times. Damaged infrastructure and navigable roads can be quickly identified to help allocate first responders.

Insurance

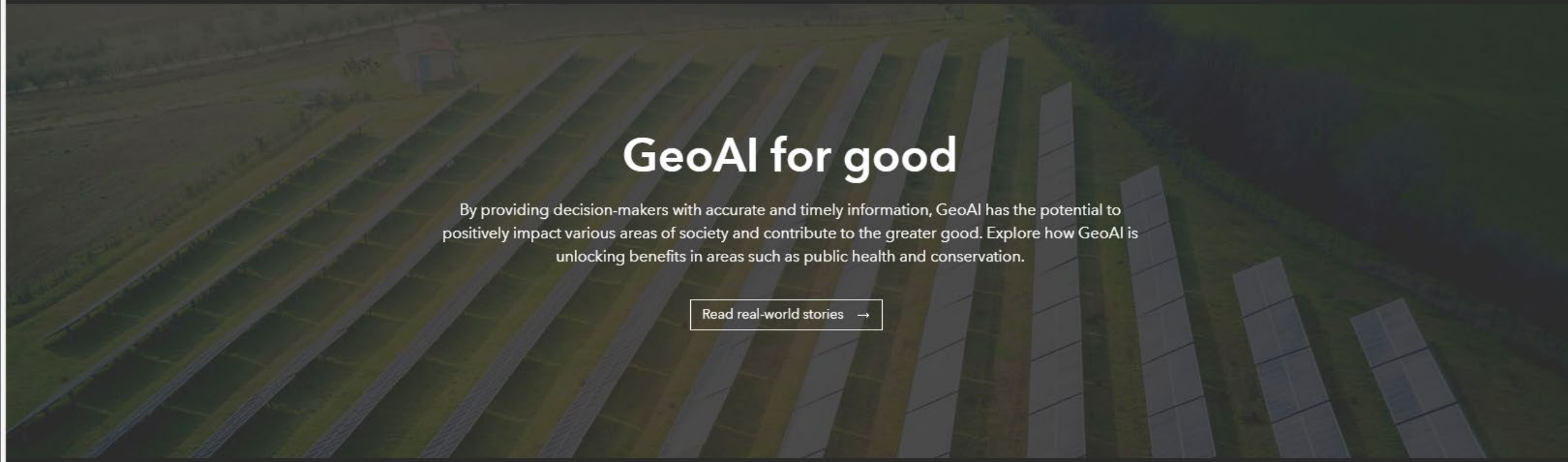
GeoAI is helping insurance organizations understand the impact of an event in hours instead of days to improve claim processing and efficiently help members. Insurance companies can use imagery and GeoAI to detect and classify damage that impacts its members. With this understanding, they can get members back on their feet more quickly.

AEC

GeoAI is transforming the architecture, engineering, and construction (AEC) industry with its ability to extract information from imagery, which feeds a digital twin. This data allows decision-makers to improve project management, identify potential risks, and optimize building performance. As a result, architecture firms can design energy-efficient buildings.

Business

GeoAI is accelerating smart business decisions, delivering insight and predictions that drive better market planning, site selection, supply chain efficiency, and customer intelligence. With these insights, a business can respond to customer behavior and determine whether a new market area is viable based on pattern and predictive analysis of market characteristics.



GeoAI for good

By providing decision-makers with accurate and timely information, GeoAI has the potential to positively impact various areas of society and contribute to the greater good. Explore how GeoAI is unlocking benefits in areas such as public health and conservation.

Read real-world stories →

Getting started with Esri

Shorten the time to insights

Combine the world's most powerful GIS and location intelligence software with the scalability and power of AI. Esri's long-standing expertise gives you a trusted solution for extracting meaning from big data. Eliminate the need for large amounts of training data, massive compute resources, and extensive AI knowledge. Modernize how you approach spatial problems at scale with Esri.

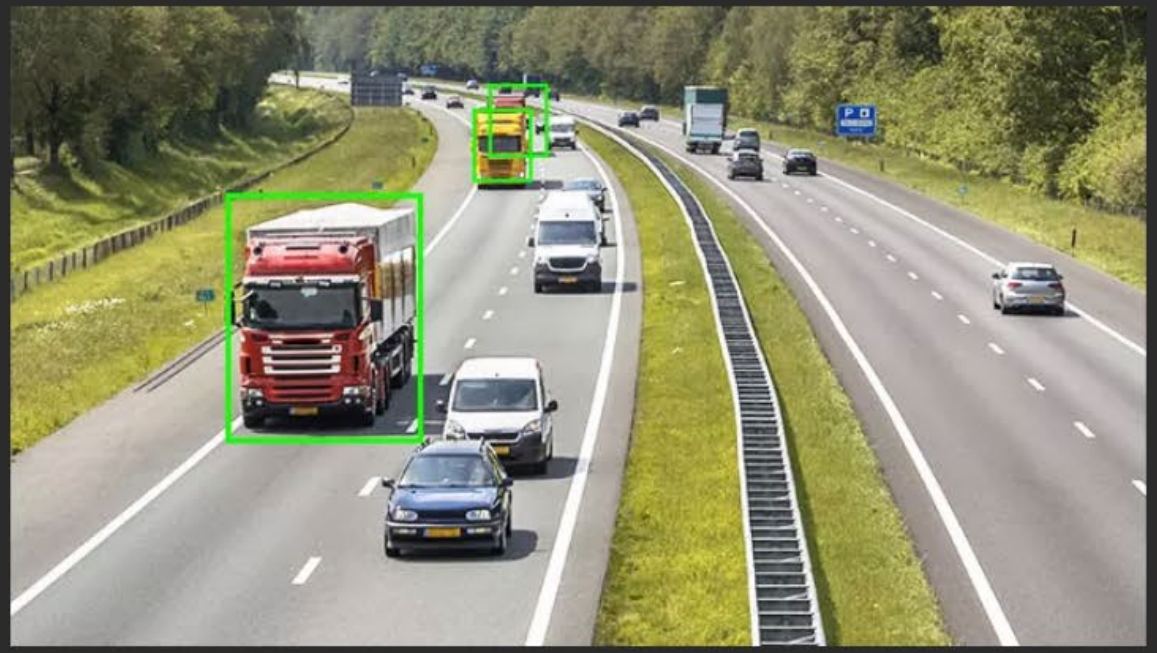
START HERE

You don’t have to start from scratch

Getting started with GeoAI can sometimes feel like a daunting task. Use pretrained deep learning models and spatial machine learning tools backed by spatial experts. Our trained deep learning models provide the means for anyone to start extracting, classifying, detecting, and problem-solving with the data you have—no training data required. And our machine learning tools allow you to get started with UI-based tools with data-driven defaults that help guide you.

Explore pretrained models →

Make predictions using ArcGIS →



FINE-TUNE TO YOUR NEEDS

Tweak our models to get them just right

With a starting point, you now have the means to focus on fine-tuning. Tweak our deep learning models and machine learning algorithms to fit your parameters and desired accuracy. We provide you the flexibility to tap into advanced settings and customize.

Learn how to fine-tune models →

Additional Resources

1. GeoAI page - https://www.esri.com/en-us/capabilities/geoai/overview
2. Kristian Ekenes' Github site - ekenes (Kristian Ekenes) - GitHub (https://github.com/ekenes)

Kristian Ekenes

ekenes

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Redlands, CA

http://developers.arcgis.com/javascript

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Call to Action

Tell us what you want or need!