GeoAI

For Resource Management Applications

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GeoAI in Federal Agencies

- Quick terminology review
- Where is AI/ML currently being used (or developed) in geospatial applications?
- Where is government/industry on GeoAI development?
- Suggested areas of focus (the List)
- A CoP strategy
  - Low hanging fruit (use cases) – where/what is it?
  - Non-profits and Academia
    - Taylor Geospatial Institute - https://taylorgeospatial.org/
  - Inclusion (cross pollination) with the vendor community
    - https://atarc.org/generative-ai-working-group/
- Where can we (the CoP) make a difference?
- Can a CoP overcome barriers to adoption, and serve as an advocate for AI/ML in Geo?

Multi-Agency GeoAI Community of Practice

A **community of practice** (CoP) is a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. A CoP seeks solutions to common problems and challenges. Responsible, strategic development of AI/ML to support geospatial and remote sensing needs is a challenge we should work collaboratively.

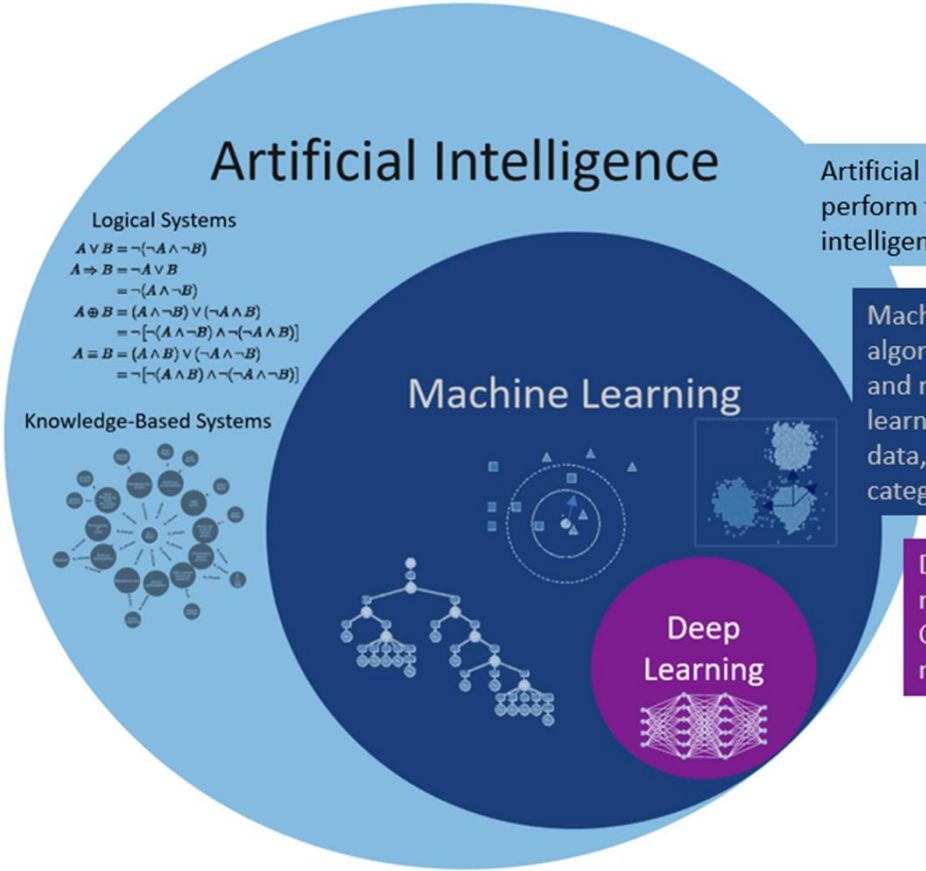
Goal: Define standards sufficient to allow flexibility of AI innovation yet maintain control as required by the Executive Office. Identify use cases and approaches to developing AI/ML algorithms.

The Geo AI CoP is intended to provide a road map for responsible use and integration:

GeoAI Community of Practice

We need a federal GeoAI Community of Practice for geospatial and remote sensing applications (data processing, data analysis, product generation, etc.). **The idea behind the CoP** is to bring the fed-civ geospatial community together to develop an understanding of the following:

1. Who is actively engaged or interested in using AI/ML in remote sensing, and for what purposes? Image processing, sensor fusion, image analysis, product generation, and product distribution.
2. What is being done in the private sector and academia?
3. Where is the low hanging fruit with the biggest benefit and lowest risk?
    a. ***Example***: Wildland fire mapping of thermal imagery to produce fire activity shapefiles for use at incident commands. Currently a person intensive task with built in latency (for product generation and distribution).
4. Which use cases outside of disaster support stand out as beneficial areas of application.
    a. Example: Image classification and segmentation. Granted this is already somewhat automated, but perhaps accuracy can be improved with introduction of ML algorithms.
5. Identify common needs and efforts between agencies and seek a holistic approach to algorithm development, where appropriate.
6. Observe guidelines being developed within the USG for generative and non-generative AI.
7. where is this heading and what will the impacts be?
8. End goal: **Work collaboratively to effectively and efficiently harness GeoAI**

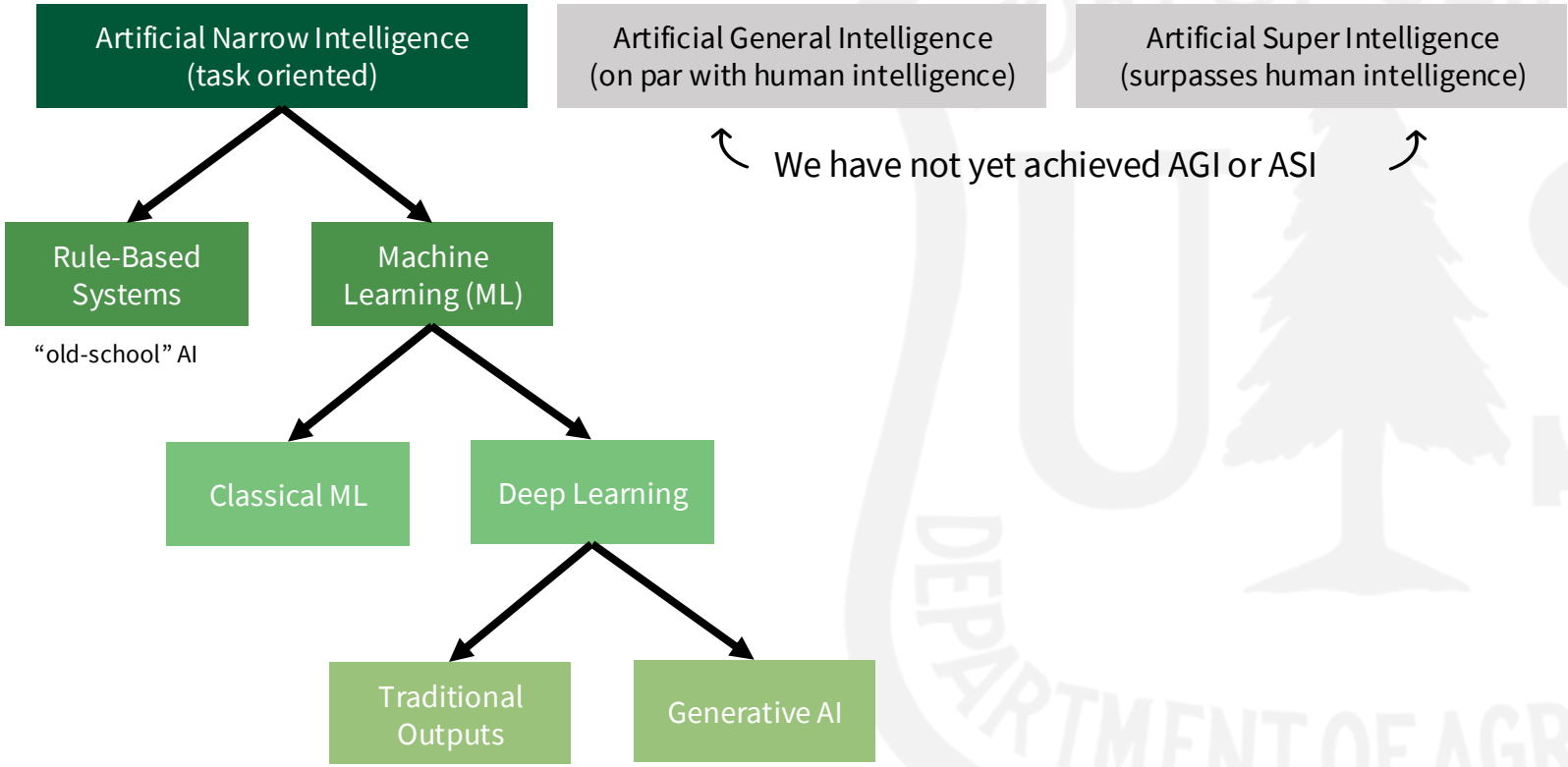


Artificial Intelligence (AI)-The ability of computer systems to perform tasks that have traditionally required human intelligence.

Machine Learning (ML)- A subfield of AI that focuses on algorithms and models that enable computers to learn from and make predictions or decisions based on data. Machine learning algorithms can be trained to identify patterns in data, make predictions, and classify data into different categories.

Deep Learning- A subfield of ML using multi-layer neural networks. Deep learning is the basis for tools like ChatGPT, Computer Vision, and other generative AI models.

Types of AI


Artificial Narrow Intelligence
(task oriented)
Artificial General Intelligence
(on par with human intelligence)
Artificial Super Intelligence
(surpasses human intelligence)
We have not yet achieved AGI or ASI
Rule-Based Systems
"old-school" AI
Machine Learning (ML)
Classical ML
Deep Learning
Traditional Outputs
Generative AI

What are the benefits of AI?

- Increased efficiency and productivity
  - **Automate repetitive tasks → workforce can focus on more creative and complex work**
- New insights, ideas, and innovations
  - **Identify patterns in data**
  - **Forecast future trends**
- Enhanced stakeholder experience
  - **Deliver services faster both internally and externally**
  - Respond to customer inquiries or complaints
  - Make personalized recommendations
- Decision support
  - **Show policymakers the potential outcomes of specific courses of action**

Where are there opportunities for GeoAI? - Examples

Wildfire

- Predict fire spread
- Detect new fire starts
- Map fire from thermal imagery
- Evaluate fuel treatment effectiveness
- Optimize response logistics

Land Management

- Detect biodiversity loss, deforestation, invasive species
- Organize, tag public comments
- Model biomes
- Augment GIS capabilities

The Lengthy List – Use Cases and General Questions

Requested/suggested areas of focus (from invitees to the CoP):

- Imagery and classification, **feature extraction** for both current and historical imagery. (J. Biediger – USDA).
- Use of ML/CNN in **image analysis** for land cover mapping, emergency response, mining and environmental protection. (D. Pilant – EPA).
- Revolution(?) toward 10m resolution CONUS Cropland Data Layers. (Z. Li – USDA)
- Interest in: pain spots tied to compute (N. Enwright USGS).
- Co-production of AI/ML research/solutions with data producers. (LaPuma USGS).
- 1. The world of point cloud data! 2. cloud storage, cloud computing, all things cloud 3. Committee / suggestions to people who can push back on barriers / advocate. 4. I would like the NASA folks to put on another 'foundation model' workshop 5. hold smaller breakouts for some topics & allow some folks interested in certain areas to network and share lessons learned. (A. Reiner – USDA).
- Live or recorded tutorials might be useful for people. (A. Pina – USDA)
- Coding for AI. (L. Juliusson – USDA)
- It is important we consider how these spatial products are being consumed within the agency(s) for other purposes such as NEPA, budget, funding allocation, etc. (M. Cleaver – USDA).
- **Machine Learning operation** (ML Ops); getting started with finding FedRAMP approved vendors for labeling, tools, deployment, etc. (G. Lederer – USDA).
- **Hyperspectral imagery** (K.Allison – USDA).

The Lengthy List – Use Cases and General Questions

Requested/suggested areas of focus (from invitees to the CoP):

- We as scientists need to be aware of limitations/issues when it comes to AI/ML. We need to make sure the wider audience understands this concept as well, so appropriate disclaimers can be made when issuing decisions and to offer stakeholders transparency with how decisions are made when using AI/ML." (M. Cleaver – USDA).
- More examples of **object detection** will be useful as well as any LiDAR/3D data processing. (G. Bacon – Fairfax County)
- **Is AI the most efficient way**? Leveraging expert knowledge. (D. Newcomb – FWS).
- **Training Data and Model Sharing Pipelines?** (A. Nash – USGS)
- **Insect and disease satellite-based change detection**, need to ensure that it is trained and tested appropriately. (Karen Hutten – USDA).
- **Generative AI and Artificial General intelligence** (AGI). (S. Magstadt – Colorado State)
- **Decision tools** rather than decision support tools. (S. Magstadt – Colorado State).
- AI assistants in wildfire management (S. Magstadt – Colorado State).
- Connections between high quality geospatial data (JACIE characterized) and AI/ML processes (R. Tetrault – USDA).
- AI/ML related to **data interoperability tools**. (J. Clauson – USGS)
- **Some tutorials on how to start using ML/AI in ArcPro** would be helpful! Curious to see how it could be used on easily accessible data (like 3DEP LiDAR data or DEMs.) – (H. Malonee – USDA).
- Machine Learning **workflows and training**. (J. Lovato – USDA).
- AI/ML camera and video **object identification** (A. Hess – EPA).

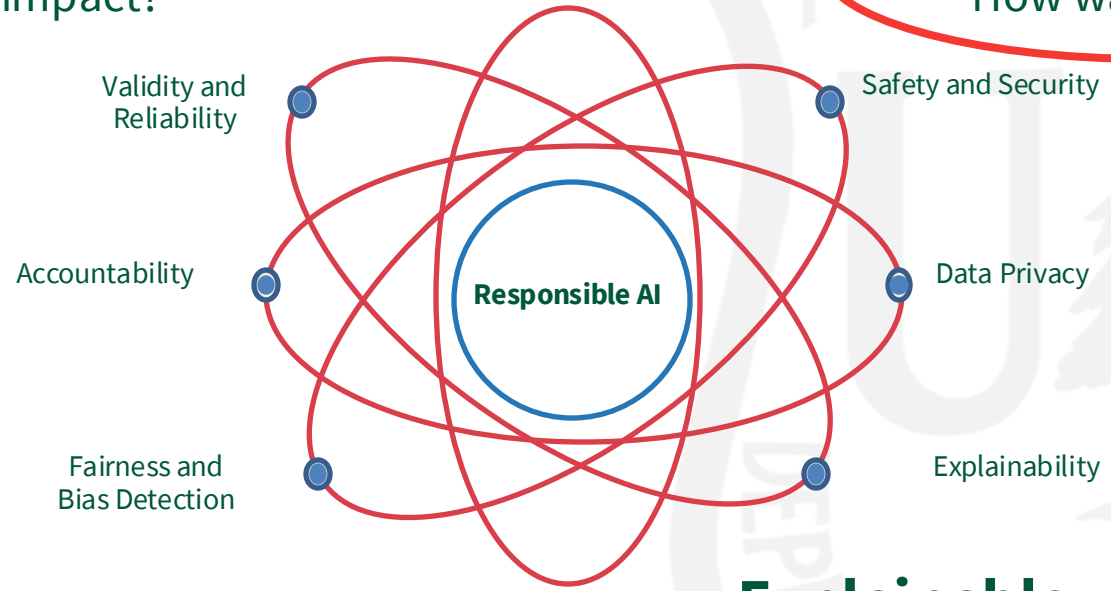
Recommendations

- Begin to build vision and roadmap for AI use / applications
  - Look for opportunities and mitigate risks: accelerate adoption and scale AI in four steps

The goal is to design, build, and deploy GeoAI responsibly

Transparent
What is its impact?

Trustworthy
How was it trained?



Explainable
How does it predict?

Everett's Closing Thoughts

- **AI/ML is coming to geospatial and remote sensing** whether we are prepared for it or not, whether we like it or not.

- **We NEED this technology** to effectively manage the ever-growing firehouse of geospatial data (collect, analyze & produce products). We can no longer manage geospatial data the way we have in the past.

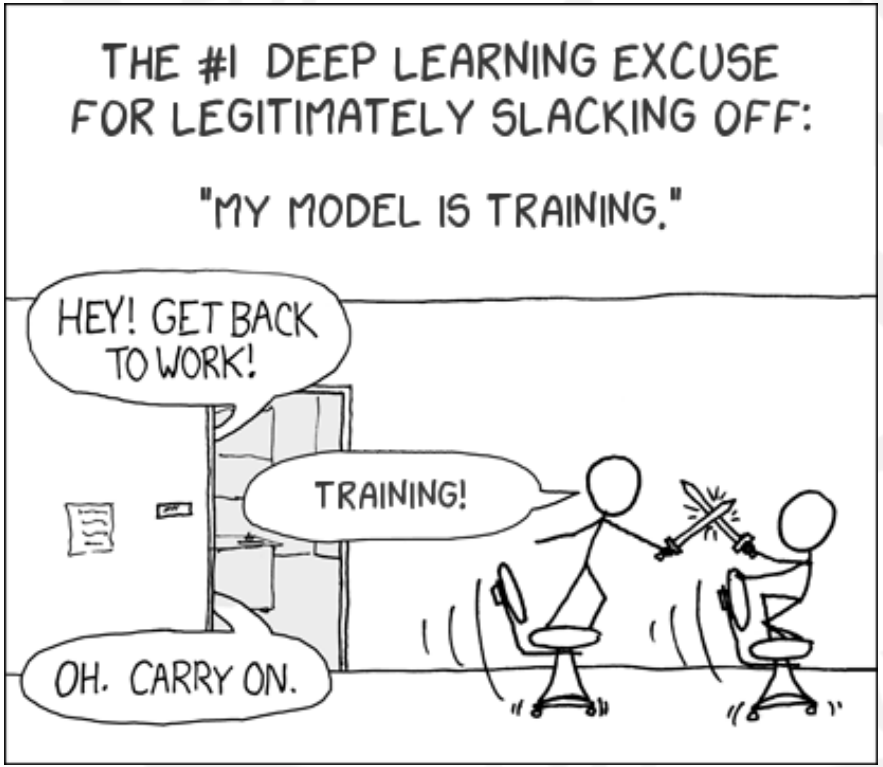
- Machine Learning may help us to see patterns that weren't obvious in the past, providing new insights into the lands we manage and to change happening on the Earth.

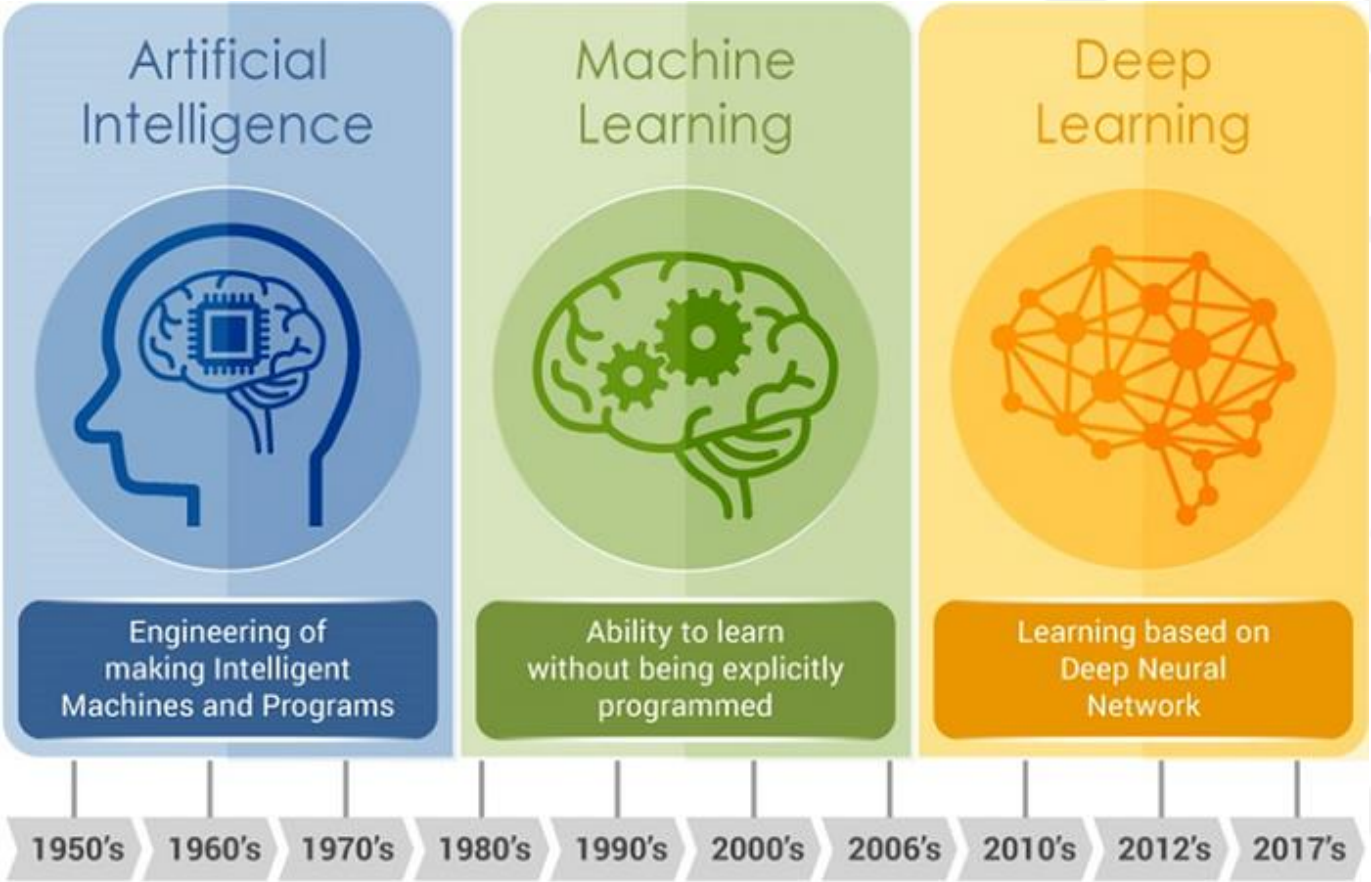
- Machine Learning will improve predictive modelling, which is key in both disaster response and to land management activities.

- The federal community needs to embrace this technology, understand the technology (the good, the bad, and the ugly), and to maintain control over the AI/ML processes. ~~No black boxes!~~

Discussion!

Back Up Slides





Why GeoAI?:

- Data streams are increasing in volume
- Data complexity is increasing
- Processing and analysis workloads are increasing.

Generative AI: Expanding the Output of AI Systems

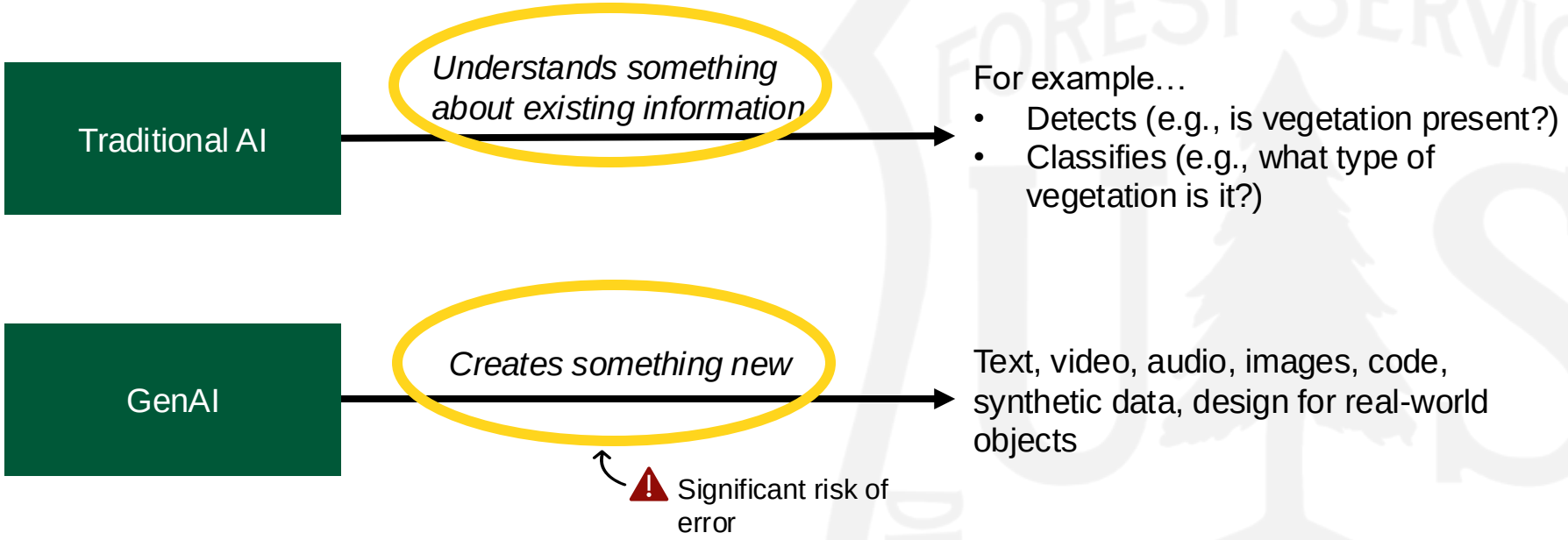
Today

AI Systems → Mostly Classify → **Symbols**
Lifetime Value Score, Intents, Risk Levels, "Turn Left, Image Category, Emotion Type …"

Emerging

AI Systems → Expand to Generate → **Artifacts**
Video, Audio, Language, Images, Code, Synthetic Data, Design for Real World Objects

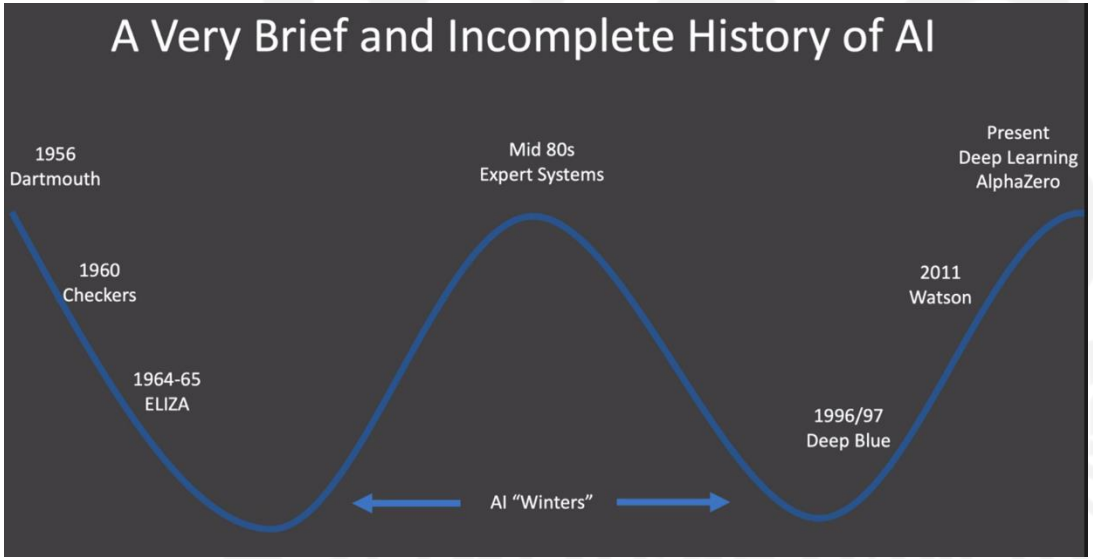
What is generative AI (GenAI)?



"Generative AI learns from existing artifacts to generate new, realistic artifacts (**at scale**) that reflect the characteristics of the training data, but don't repeat it. It can produce a variety of **novel content** such as images, video, music, speech, text, software code and product designs." -- *Gartner*

AI is not new, but the widespread availability of AI is new

- AI in some form has been around for decades
  - R&D has been using it for a while
- What is new is the ability to **scale AI**
- Why? Exponential growth in:
  - **Data**
  - **Computing power**
- Allows algorithms to be trained with vast amounts of data samples



Source: John Bansemer, Georgetown Center for Security and Emerging Technology

Everyone is talking about AI…What does leadership need to know?

Using AI is risky; ignoring AI is riskier

OMB expects agencies to innovate

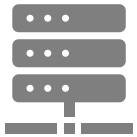
Resources and data quality are a concern

> **AI will transform most, if not every aspect of humanity…**
>
> *LINK: GSA Centers of Excellence*

GenAI can create different types of output

Natural Language

- Answers to questions
- Summaries of documents and data
- Briefing papers
- Talking points
- To-do lists
- Translation
- Tone transformation (e.g., technical to plain language)
- Code explanation



Programming and Data

- Code
- Training data

Audio and Visual

- 2D/3D faces and bodies
- Drawings
- Photorealistic images
- Voices
- Music

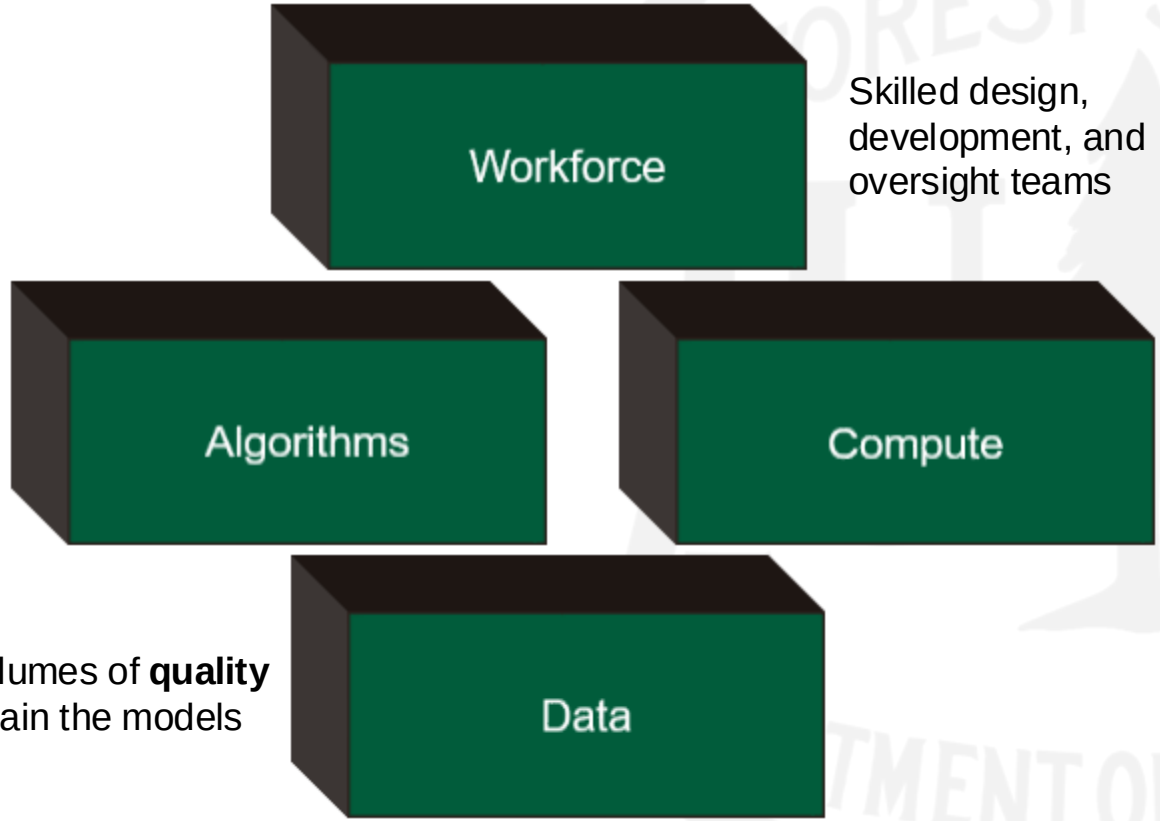
Design

- Product designs
- Business process flows
- Architectural designs and models
- Schematics

Human oversight is critical (“human in the loop”)

Managing expectations will be important

What do we need to develop and deploy AI?



The biggest obstacle is often data (!!)

- "Usually, the biggest challenges relate to getting sufficient high-quality training data" DOD, Joint AI Center
- **A Gartner survey of 698 organizations identified data as the top obstacle to AI implementation**:

In the Forest Service, obstacles 1 and 3 are critical

Guidance exists, and more is forthcoming

ⓘ *EO 14110*
ⓘ *Responsible AI*

Published

- EO 13960: Promoting the Use of Trustworthy Artificial Intelligence in the Federal Government (December 3, 2020)
- AI in Government Act of 2020 (December 27, 2020)
- NIST AI Risk Management Framework (January 26, 2023)
- **Interim Guidance on the Use of Generative AI at USDA (October 16, 2023)**
- **EO 14110: Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (October 30, 2023)**

Forthcoming

- **OMB Memo: Advancing Governance, Innovation, and Risk Management for Agency Use of Artificial Intelligence** (public comment closed December 5, 2023)
- Federal legislation?
  - CREATE AI Act of 2023
  - Proposed European Union legislation: The Act | The Artificial Intelligence Act

OMB is directing agencies to increase AI maturity

Requirements to Implement AI

Indications from the White House, supported by expert opinion, are to **start planning and innovating now**

> "Agencies **must increase their capacity** to successfully and responsibly adopt AI, including generative AI, into their operations…
>
> If implemented responsibly, AI can improve operations and deliver efficiencies across the Federal Government. Agencies **must improve their ability to use AI** in ways that benefit the public and increase mission effectiveness, while recognizing the limitations of AI and when it is not suited for a given task. To achieve this, agencies should **build internal enterprise capacity** to support responsible AI innovation and take actions to improve their procurement of AI."
>
> LINK: Draft OMB Memo, Advancing Governance, Innovation, and Risk Management for Agency Use of Artificial Intelligence

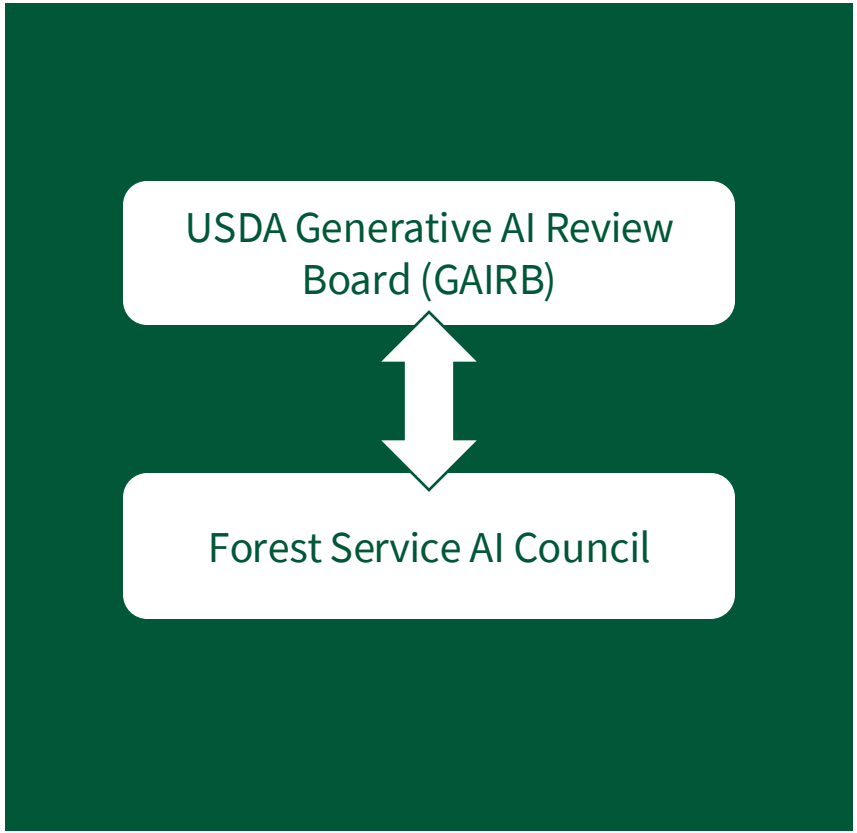
Innovate to learn how best to manage risk

Develop governance

Promote ethical AI use

A governance framework will mitigate risk

ⓘ *Council Structure*



Forest Service AI Council will lead **responsible AI** through **innovation** and **collaboration** to unlock AI's potential to solve complex natural resource and organizational management issues

- Establish AI governance for Forest Service
- Promote responsible AI curriculum & facilitate learning and growth
- Ensure alignment with USDA and Federal policy
- Seek USDA GAIRB's approval for GenAI use cases

Recommendations

Support the formation of proposed AI Council

Continue dialogue to reimagine business models

- Unique opportunity to transform old models and rethink the art of the possible

> **We are past the point where human cognitive abilities can directly process and make sense of all this information…**
>
> *Most federal agencies know that input **data volumes are increasing relentlessly and not being handled thoroughly**. In the past, we have blamed this kind of shortfall on lack of personnel, supplies, or equipment. But while these factors are still true, there **is no practical increase in any of those resources that would itself suffice** to address the new information volumes…*
>
> *The use of AI will enable the agencies to handle millions or billions of data inputs with a feasible level of personnel and funding."*
>
> LINK: GSA - IT Modernization Centers of Excellence

GenAI has strengths… and weaknesses

Strengths	Weaknesses
• Knows a lot: has read more than any human • Speaks many languages • Produces responses very fast • Can “converse” with user and iterate on output • Learns from what it is given • Can use reason in developing responses	• **Hallucinates**: makes up things that may appear authoritative • Only knows the data it's been trained on • Will reflect biases in training data • May not understand sensitivity or privacy • May be naïve; has no real-world experience

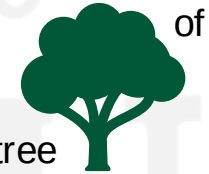
Managing weaknesses requires active human oversight (“human in the loop”)

Return

How is Forest Service currently using AI?

Evaluating landscape conditions and outcomes across future management scenarios

Tree-level modeling of US forests



Classifying continuous tree canopy cover

Producing raster maps of forest resources

Modeling habitat suitability for tree species under varying climate conditions

Testing AI for categorizing public comments

Identifying building loss in the WUI after wildfire

Monitoring landscape changes

Forest Service AI Inventory

- FS AI currently uses basic Machine Learning (ML) solutions

Category	# of Use Cases Identified in 2023 Inventory	Examples
Geospatial Augmentation/ Remote Sensing	5	• Ecosystem Management Decision Support System • National Land Cover Database, Tree Canopy Cover Mapping
Modeling	5	• TreeMap 2016 • Landscape Change Monitoring System
Knowledge Integration	1	• Cross-Laminated Timber Knowledge Database

Source: AI Inventory

Research & Development is engaged on multiple fronts, e.g., working with EMC to test AI for comment categorization

AI Inventory

Public: Government Use of AI - AI.gov (updated annually)
USDA: AI Inventory (sharepoint.com) (ongoing updates)

Requirements to Scale Responsible AI

RESPONSIBLE AI

AI & Data Delivery

- Data strategy & architecture
- AI capabilities
- AI experience

Experimentation, Testing, Enablement

GPU capacity forecasting

LLM fine-tuning

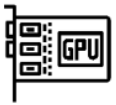
ESG impact estimation

Edge compute & AI inference

Total cost of ownership estimation

Computer vision, digital twins, and more

High-Performance Architecture



Compute accelerators

Network

Storage

CLOUD OR ON-PREM

Source: World Wide Technology