

The Burgeoning AI Model Ecosystem and Its Impact on GIS

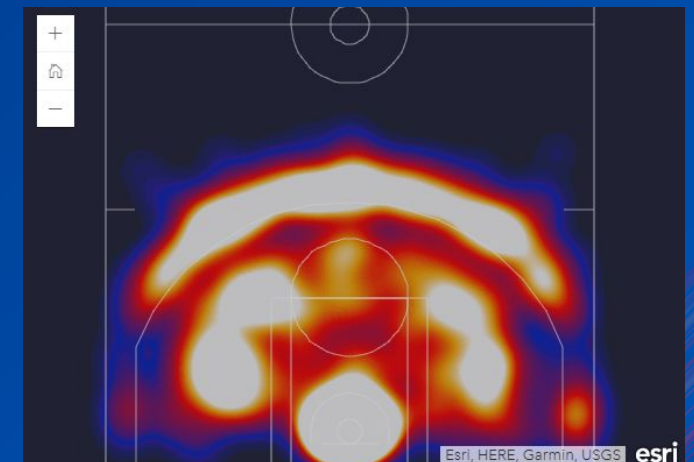
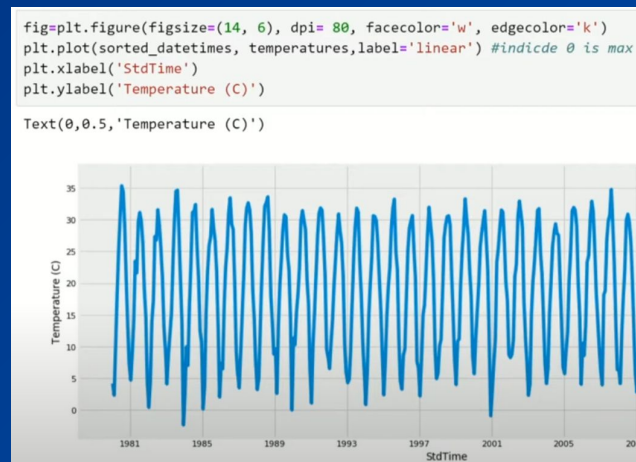
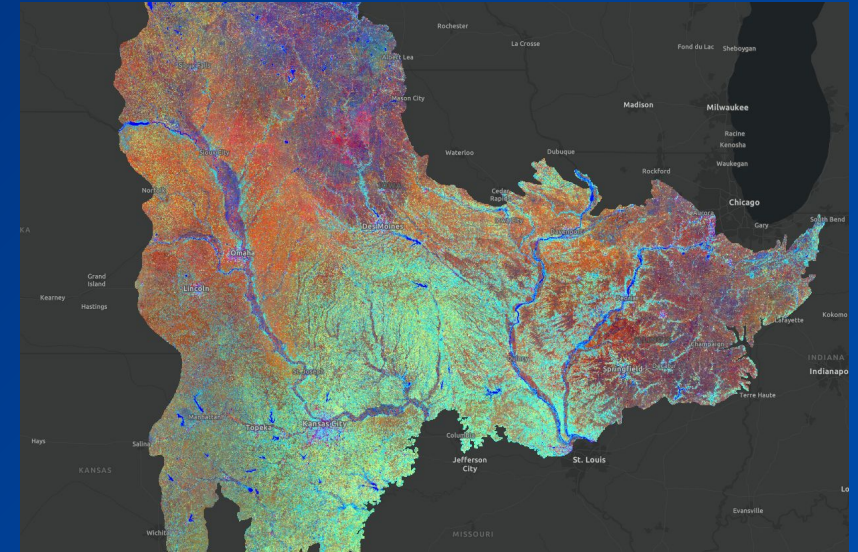
Gregory Brunner, Esri



Who am I?

Principle Data Scientist, Esri

- B.S. & M.S. in Physics
- Research in Astronomy
- Learned GIS in first job at Sensing Strategies, Inc.
- Consultant at Esri since 2011



Esri, HERE, Garmin, USGS esri

Three Takeaways for Geospatial AI in 2024



Your spatial data can be used to prompt non-spatial AI models



Just like the pharmaceutical industry repurposes drugs, we can repurpose AI models



Learn Hugging Face and the Python Transformers library



Where to start...



What is a geoprompt?

- A geoprompt is a mode of interaction with an artificial intelligence model where the input prompt is a geographic or spatial feature. This includes, but is not limited to, a point on a map, a polygon on a map, or an image.

Why is this relevant?

- ChatGPT takes text prompts and image prompts as its input
- We can use a feature on a map or an image as a prompt to an AI model
 - Just like you prompt ChatGPT with a sentence, we can prompt a model with a geographic feature or array of pixels
- The features detected using object detection AI models can be used as geoprompts, for example, to segmentation models like Meta's SAM
- AI models can be used in concert to perform pinpoint 2D and 3D extraction
 - CLIPSeg (for pixel classification) + SAM (segmentation)
 - OWLv2 (for object detection) + SAM (segmentation)
 - Grounding DINO (for object detection) + SAM (segmentation)
- A concept you'll hear more about in the future

Models, models, everywhere!

But where to find them and which to use

- ArcGIS Living Atlas

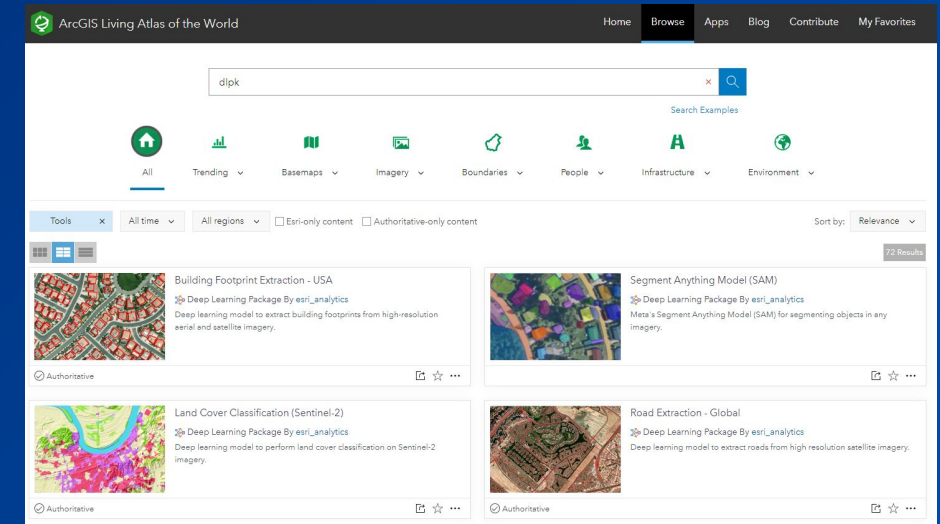
- Models for specific GIS related tasks
- Models for detecting objects
- 75+ pretrained models

- Hugging Face

- GitHub for AI Models
- 1M+ AI models

- Other sites

- GitHub
- Replicate.com
- AWS, Azure, etc.



ArcGIS Living Atlas



Hugging Face

A broader strategy to leverage AI

Does it make sense to train your own models?

- AI models developed and trained without a spatial or geographic context can be repurposed to be used within a spatial or geographic context
- Models can be repurposed, enhanced, and manipulated
- Don't start from scratch

Zuckerberg's Meta Is Spending Billions to Buy 350,000 Nvidia H100 GPUs

In total, Meta will have the compute power equivalent to 600,000 Nvidia H100 GPUs to help it develop next-generation AI, says CEO Mark Zuckerberg.



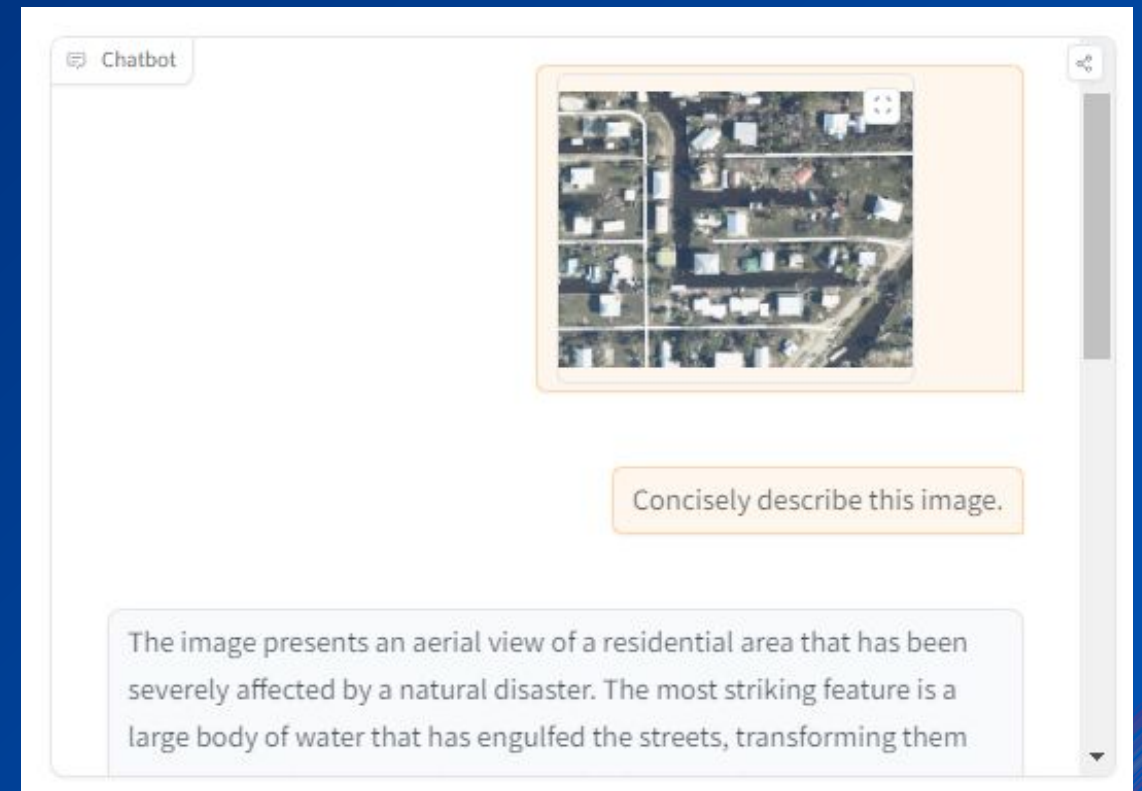
By [Michael Kan](#) January 18, 2024



Use your spatial data as a prompt to an AI model

Instead of trying to create new data with AI, why not use it to validate or enhance existing data?

- Common use for GeoAI - detecting building footprints, detecting roads, finding objects
- Newer idea – Use LLM or Image-Text-to-Text model to ask questions about your data.
 - Does this building still exist?
 - What color is this object?
 - What material is this object comprised of?



Asking LLaVA-Llama-3-8B to describe a photo of hurricane damage

Bringing AI into ArcGIS

Includes the packages needed to leverage AI in GIS

The screenshot shows the ArcGIS Pro Package Manager window. The interface includes a sidebar with navigation options like 'New', 'Open', 'Info', 'Save Project', 'Save Project As', 'Portals', 'Licensing', 'Options', 'Package Manager', 'Add-In Manager', 'Help', 'About', 'Learning Resources', and 'Exit'. The main area is titled 'Package Manager' and contains a search bar, a list of installed packages, and details for the selected 'huggingface_hub' package.

Package Name	Version
toolz	0.12.0
torch-cluster	1.6.3
torch-geometric	2.4.0
torch-scatter	2.1.2
torch-sparse	0.6.18
torch-spline-conv	1.2.2
torchvision	0.15.2
torchvision-cpp	0.15.2
tornado	6.3.3
tqdm	4.65.0
traitlets	5.5.0
transformers	4.36.2
trimesh	2.35.39
truststore	0.7.0

huggingface_hub
Package details are not available
Latest Version: 0.25.1
Installed: 0.20.3
License: Apache-2.0
Size: 265.33 KB
Dependency: filelock, fsspec >=2023.5.0, packaging >=20.9, python >=3.8, pyyaml >=5.1, requests, tqdm >=4.42.1, typing-extensions >=3.7.4.3

This tutorial card features a background image of Python code and the word 'PYTHON' in large white letters. The title is 'Create a Python script tool' and the subtitle is 'Learn how to convert a Python script to a geoprocessing Python script tool.' The estimated duration is 1 hour and 30 minutes, and the difficulty level is Intermediate.

1hr(s) 30mins **Intermediate**

This tutorial card features a background image of a neural network diagram. The title is 'Get ready for deep learning in ArcGIS Pro' and the subtitle is 'Install the deep learning libraries needed to run deep learning workflows in ArcGIS Pro, and learn to troubleshoot the most common issues.' The estimated duration is 15 minutes, and the difficulty level is Intermediate.

15mins **Intermediate**

[Esri/deep-learning-frameworks](https://www.esri.com/deep-learning-frameworks)

Getting AI into GIS via Python

Examples



Segment Anything Model (SAM)

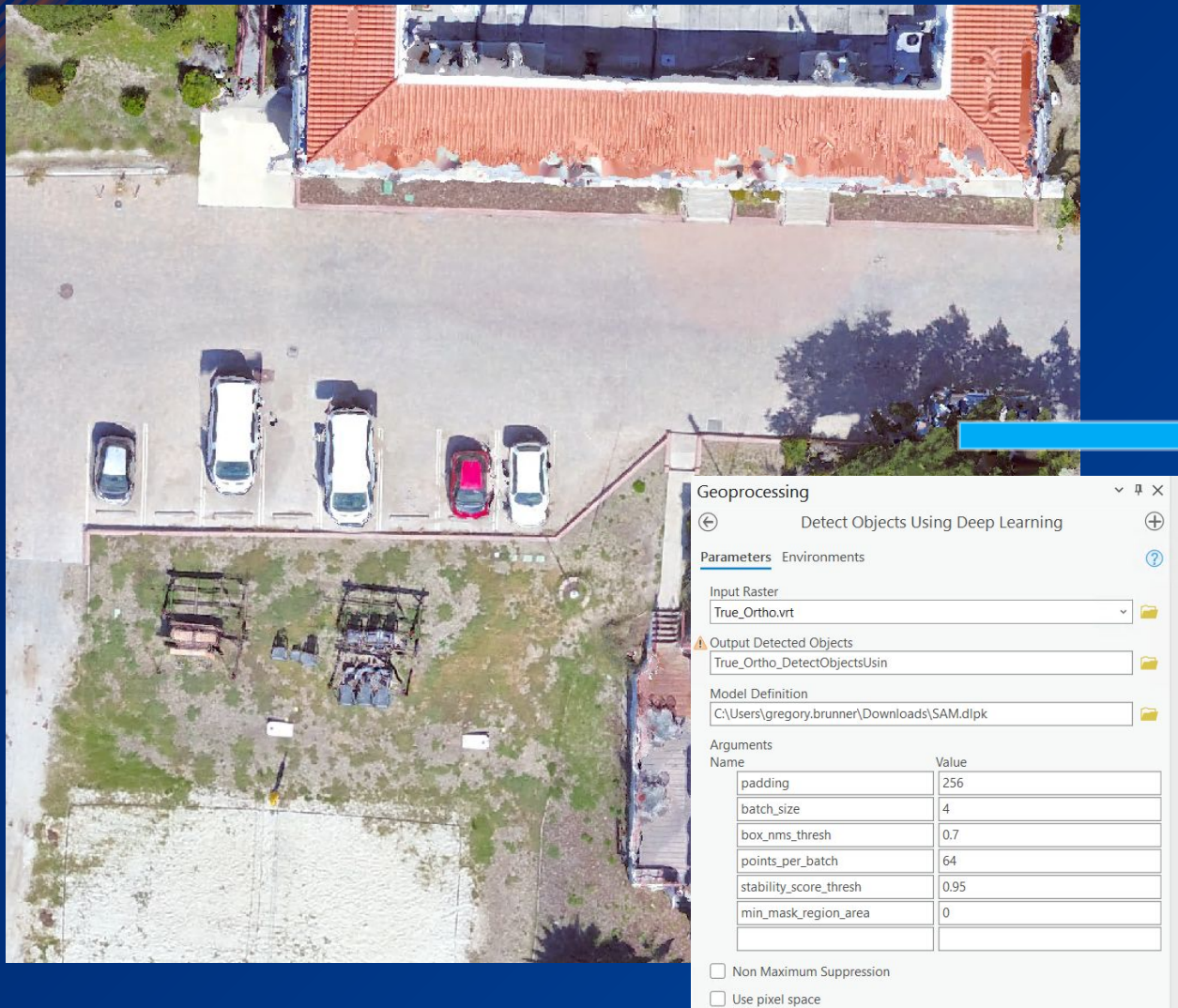
AI model from Meta that can extract any object in any image



<https://segment-anything.com/>

SAM Implemented in ArcGIS

Customized to use on imagery in geographic space



The image shows an aerial photograph of a building with a red roof and a parking lot with several cars. A blue arrow points from the original image to a processed version on the right. A Geoprocessing tool window is overlaid on the image, displaying the following parameters:

Geoprocessing
Detect Objects Using Deep Learning

Parameters Environments

Input Raster: True_Ortho.vrt

Output Detected Objects: True_Ortho_DetectObjectsUsin

Model Definition: C:\Users\gregory.brunner\Downloads\SAM.dlpk

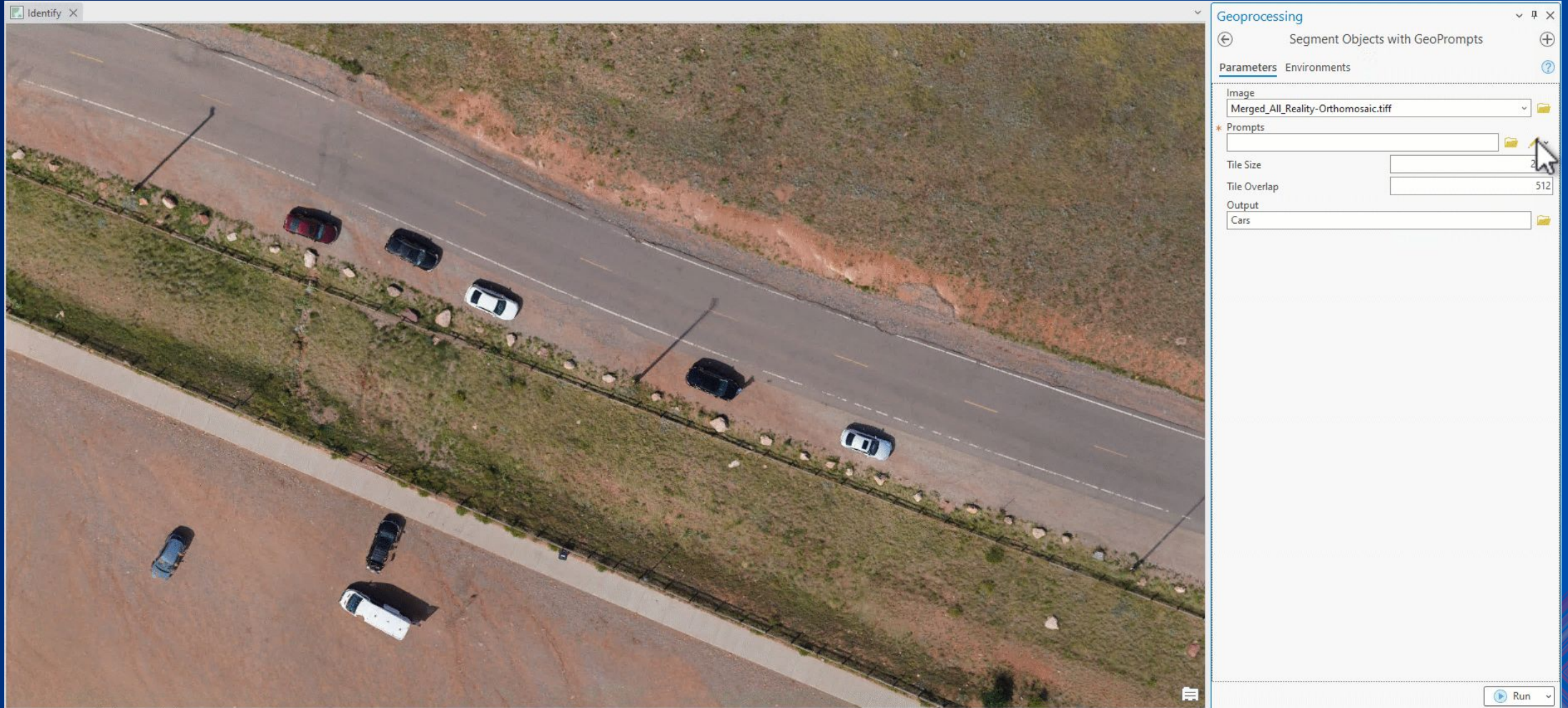
Arguments Name	Value
padding	256
batch_size	4
box_nms_thresh	0.7
points_per_batch	64
stability_score_thresh	0.95
min_mask_region_area	0

Non Maximum Suppression
 Use pixel space



Segmenting user defined objects with SAM

A custom GP tool being prototyped to segment objects based on spatial\geographic prompts



It's the same model

- Used on

- Photos
- Aerial imagery
- With geoprompts (spatial prompts)

- Available on

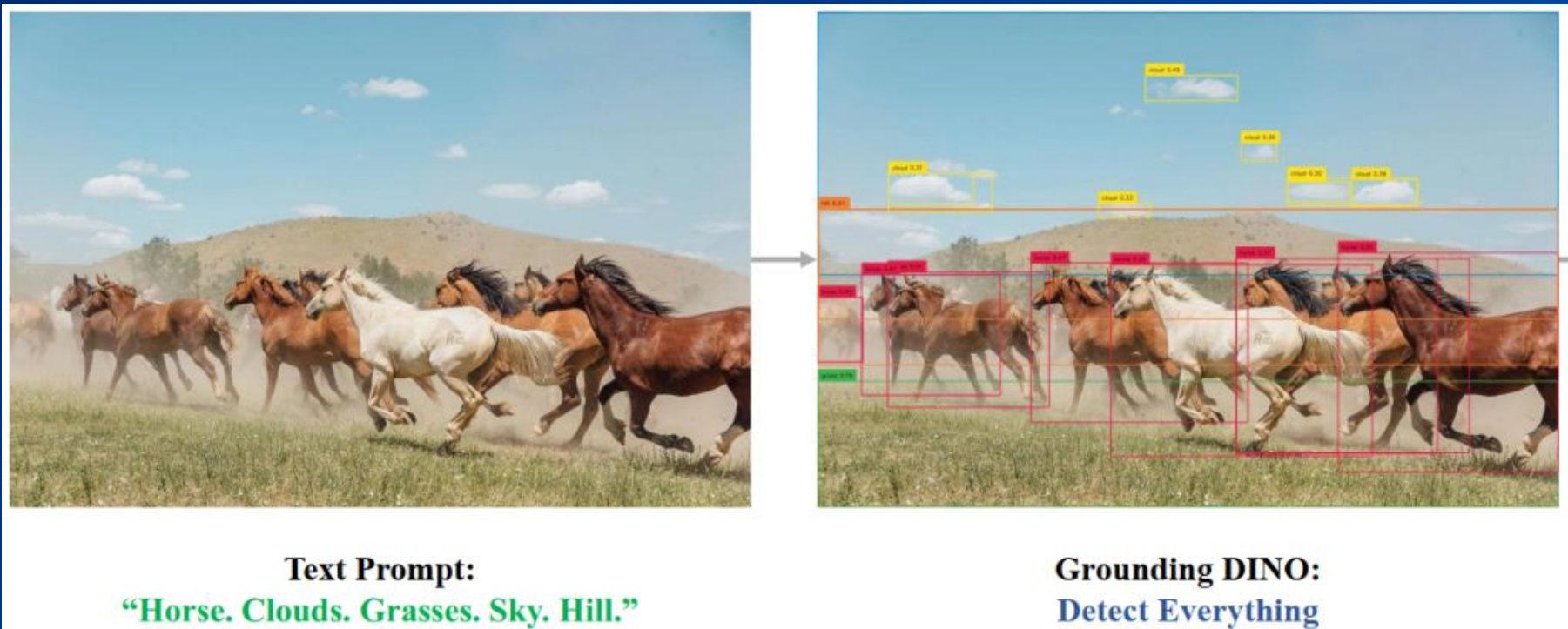
- Hugging Face
- ArcGIS Living Atlas
- Github



Grounding DINO – Detecting objects with text prompts

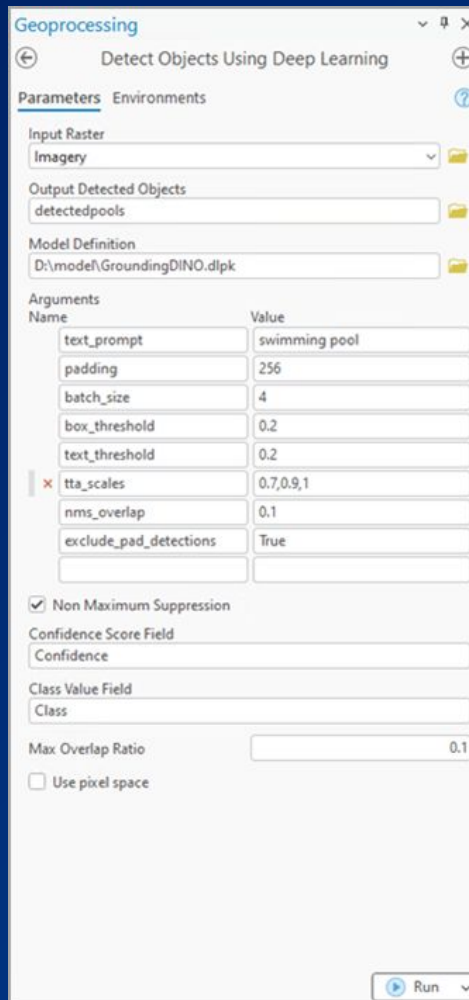
By IDEA-Research

- Text prompt – keyword, phrase of sentence use as input to an AI model
- Zero-shot learning – model not explicitly trained to detect all possible classes
- Grounding DINO – Zero-shot model for object detection



Grounding DINO – Implemented in ArcGIS

Example of detecting “swimming pools”

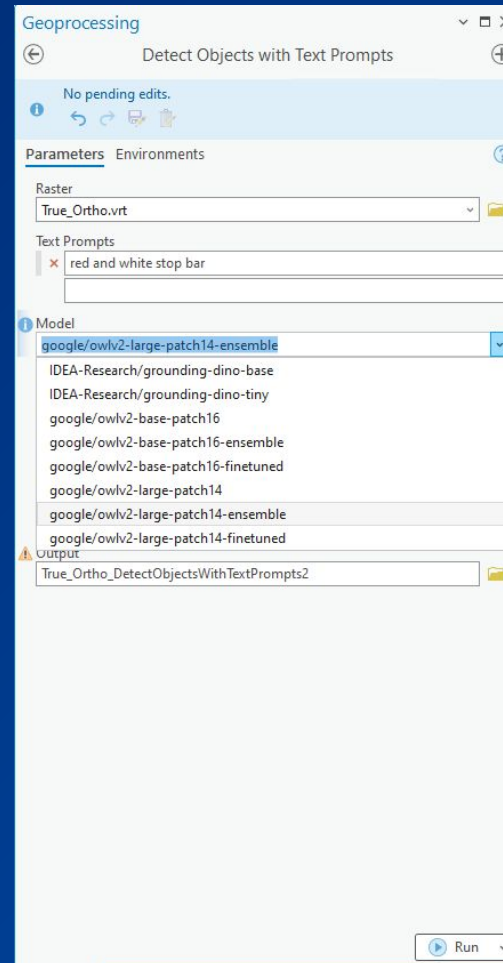


<https://www.arcgis.com/home/item.html?id=e60d974556fa45db95f5bf73caf2421a>

Beyond Grounding DINO

Integrating additional models using Python, transformers, and geoprocessing

- DINO isn't the only model!
 - CLIP
 - CLIPSeg
 - OWL-ViT
- Geoprocessing framework opens many possibilities



“red and white stop bar”

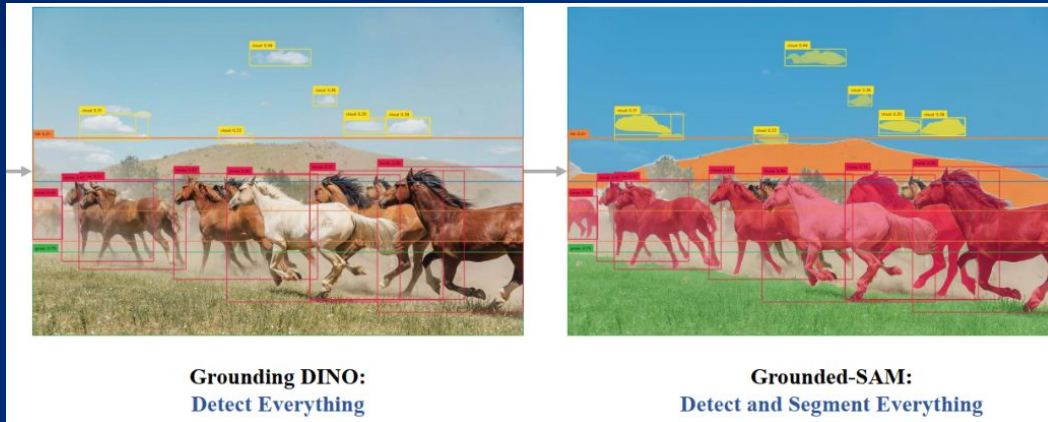
Emerging Trends

Gregory Brunner, Esri

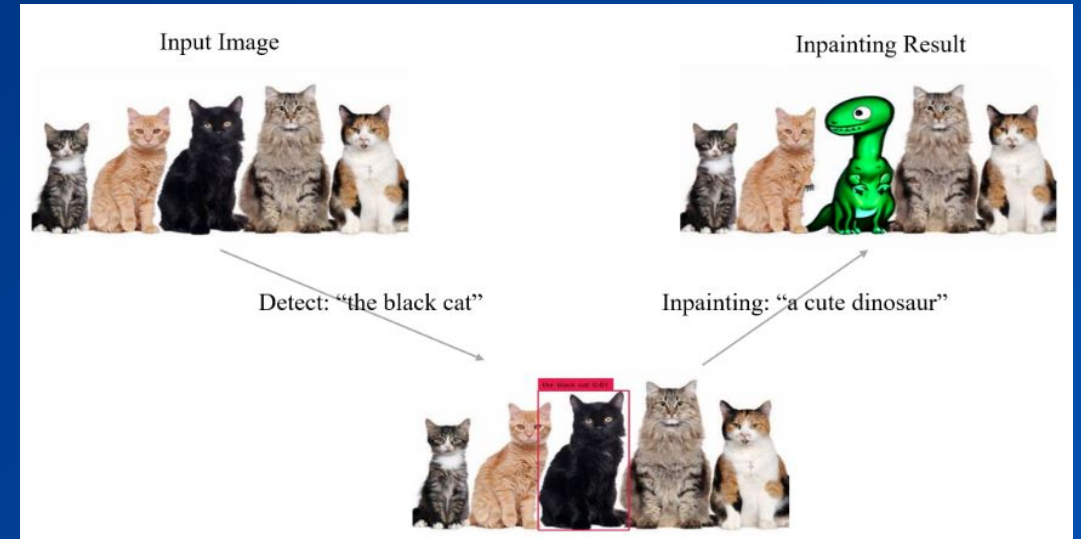


Chaining Models

AI can be even more powerful when models are used in concert



Grounding DINO + SAM -> Grounded-SAM

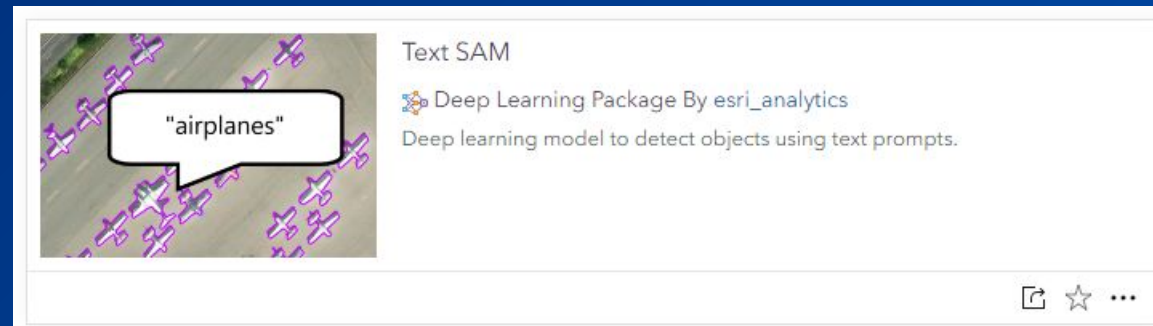


Grounding DINO + Stable Diffusion

Prompting SAM

- Combining Grounding DINO with SAM
- SAM can be prompted with points or bounding boxes (shown earlier)
- Bounding boxes can be obtained with Grounding DINO

Object Detection (w/Grounding DINO) + SAM = Object Segmentation (Text SAM)



Text SAM

Grounding DINO + SAM

Geoprocessing Detect Objects Using Deep Learning

Parameters Environments

Input Raster
True_Ortho.vrt

Output Detected Objects
kayak

Model Definition
C:\Users\gregory.brunner\Downloads\TextSAM.dlpk

Name	Value
text_prompt	kayak
padding	256
batch_size	4
box_threshold	0.2
text_threshold	0.2
tta_scales	1
nms_overlap	0.1

Non Maximum Suppression
 Use pixel space

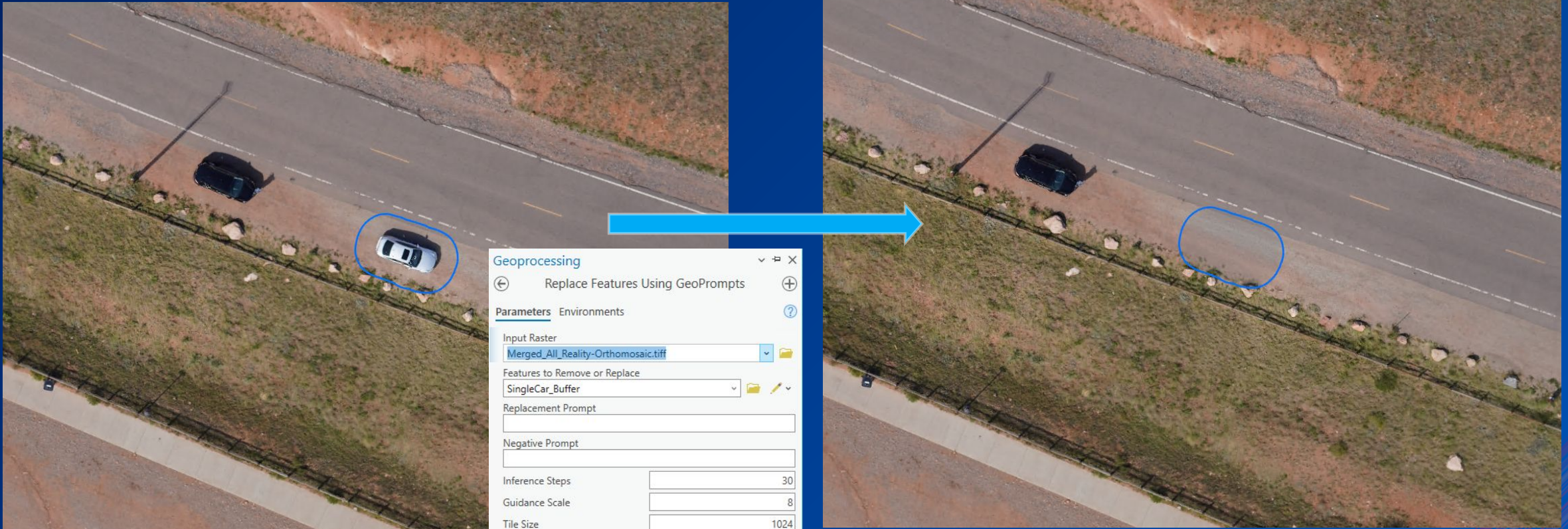
Run



Detecting & segmenting kayaks

Object Detection + Diffusion Models

Detecting cars then removing them with a diffusion model



The image shows a two-part process. On the left, an aerial orthomosaic of a road has a white car circled in blue. A large blue arrow points to the right, where the same orthomosaic is shown but the white car has been removed, leaving a rectangular patch of ground also circled in blue. In the center, a software interface window titled 'Geoprocessing' is open, showing the 'Replace Features Using GeoPrompts' tool. The 'Input Raster' is 'Merged_All_Reality-Orthomosaic.tiff' and the 'Features to Remove or Replace' is 'SingleCar_Buffer'. The 'Replacement Prompt' field is empty. The 'Inference Steps' are set to 30, 'Guidance Scale' to 8, and 'Tile Size' to 1024. The 'Adjust Tile Size' checkbox is checked. The 'Output' is 'Car_Replaced'. The 'Output as Mosaic Dataset' checkbox is unchecked. The 'Mosaic Tiles Output Folder' is empty.

Geoprocessing

Replace Features Using GeoPrompts

Parameters Environments

Input Raster
Merged_All_Reality-Orthomosaic.tiff

Features to Remove or Replace
SingleCar_Buffer

Replacement Prompt

Negative Prompt

Inference Steps 30

Guidance Scale 8

Tile Size 1024

Adjust Tile Size

Tile Overlap 256

Output

Car_Replaced

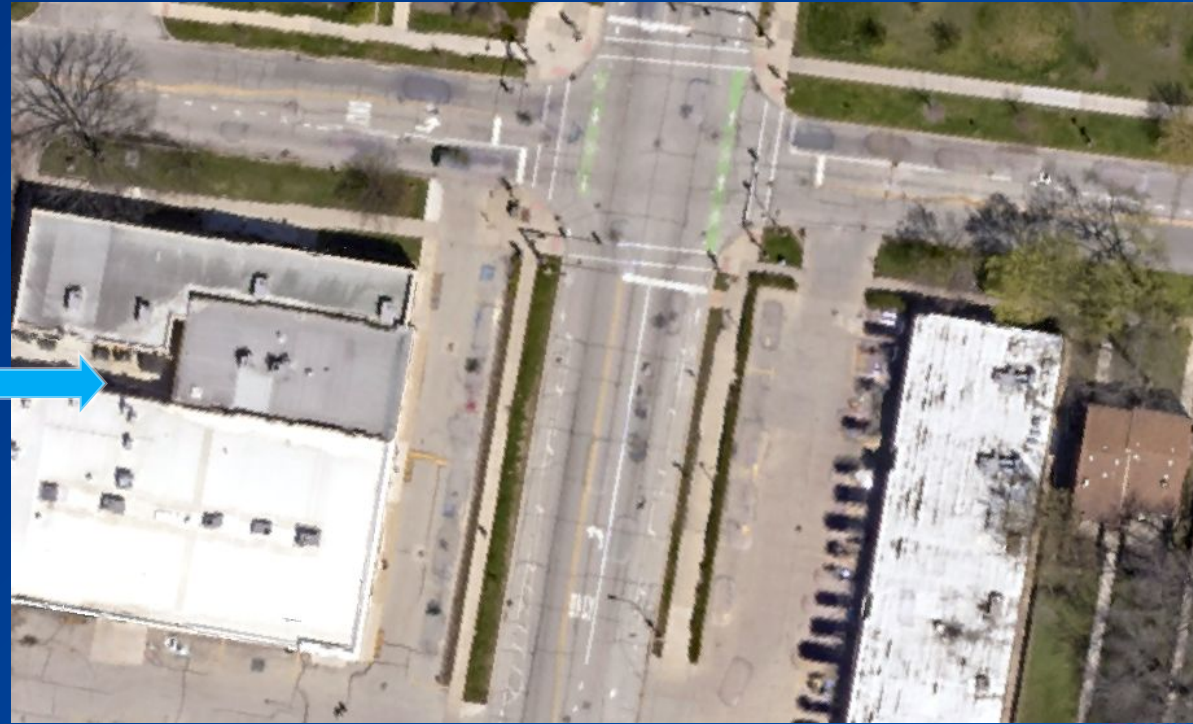
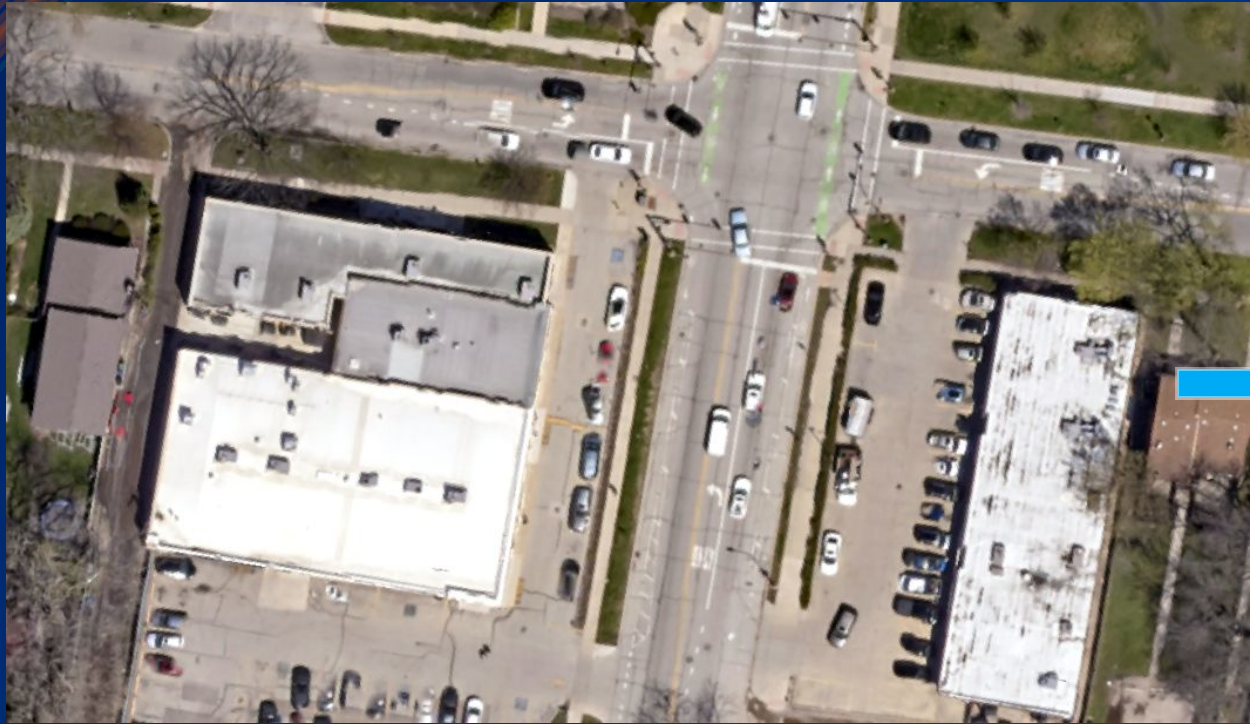
Output as Mosaic Dataset

Mosaic Tiles Output Folder

Capability in research and development

Other Examples

Removing all cars from a city street



Object replacement with diffusion models

Replacing objects with a “pool from above”

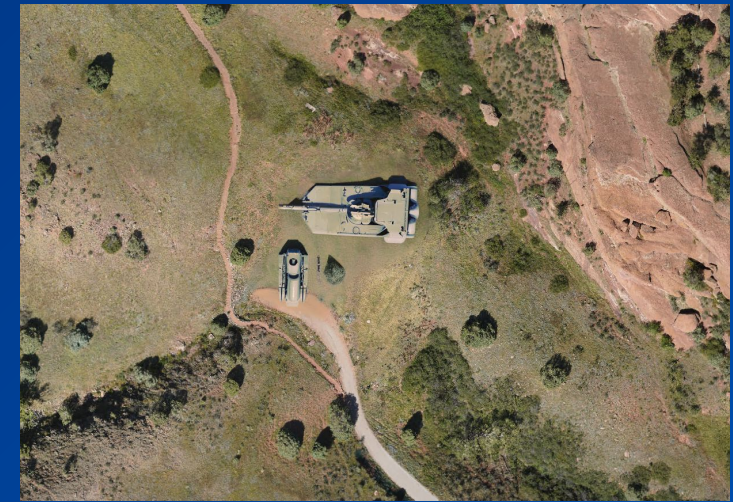


Has implications for geodesign

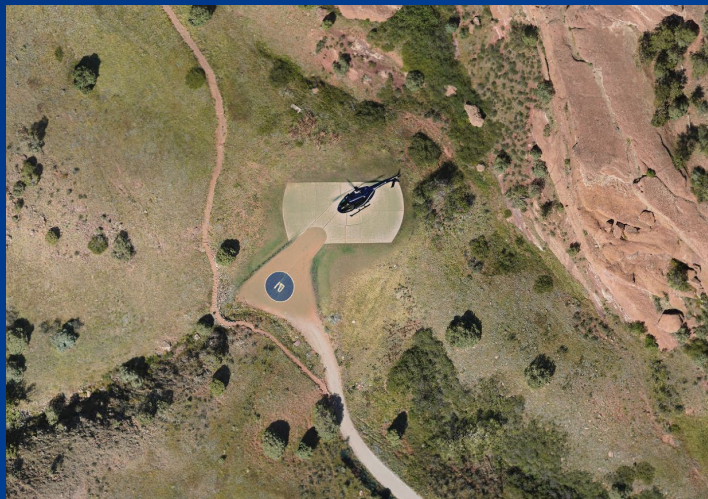
Generative AI as a Planning Tool



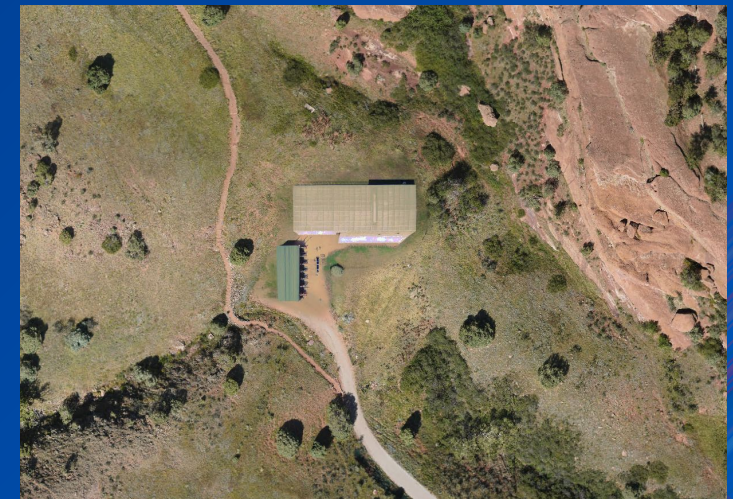
“military tank”



“two military tanks”



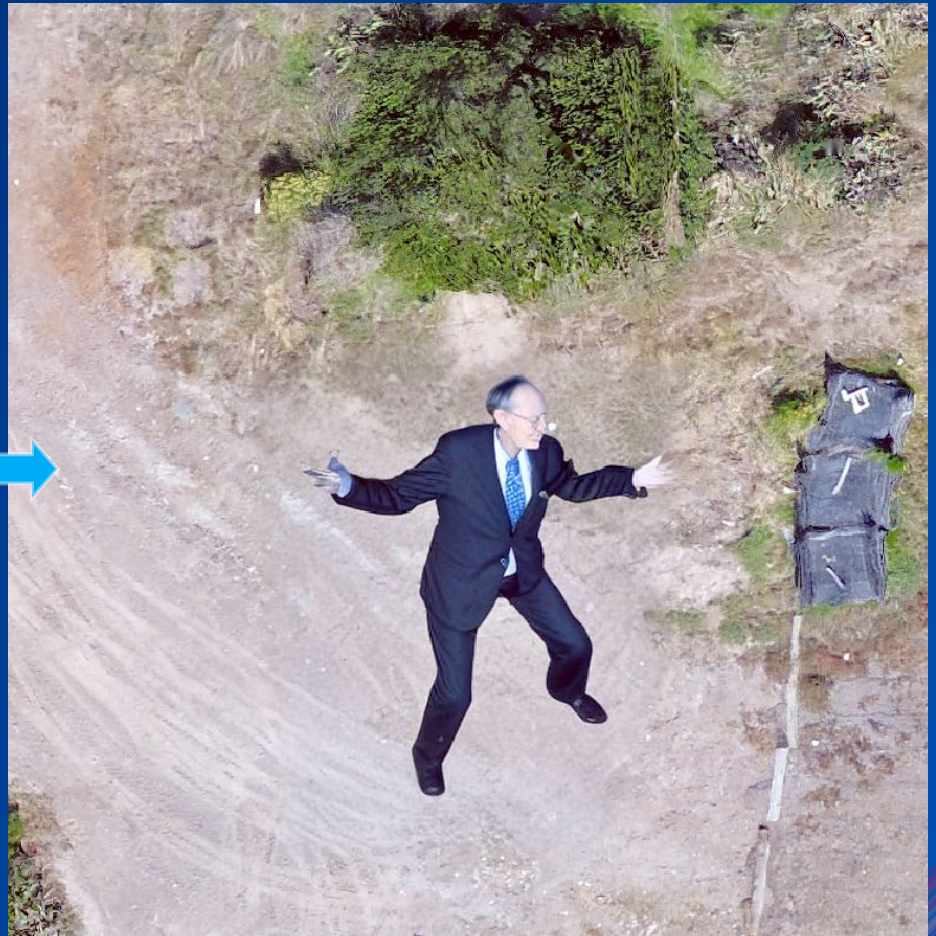
“helicopter landing pad with helicopter”



“warehouse”

Object replacement with diffusion models

Replacing objects with “Jack Dangermond waiving”



Sometimes, I just use it for a laugh

Large Language Models (LLMs) and Foundation Models

- LLMs and Foundation Models
 - Billions\trillions of parameters
 - Trained on Internet scale data
 - Language, vision, speech...multi-model
- Sparks of Artificial General Intelligence (AGI)
 - Understand and generate *human-like* text\images
 - Can be *prompted* to perform many down stream tasks
 - *No training necessary!*



AI Assistants in ArcGIS

Leveraging LLMs and Generative AI

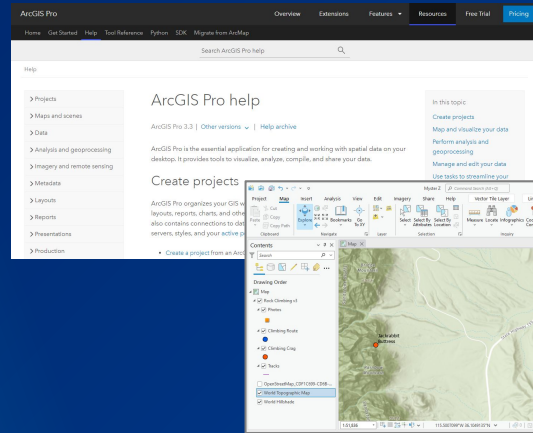
Assistants for...

- Mapping
- Analysis
- App Creation
- Data Management
- Administration
- Search
- Learning

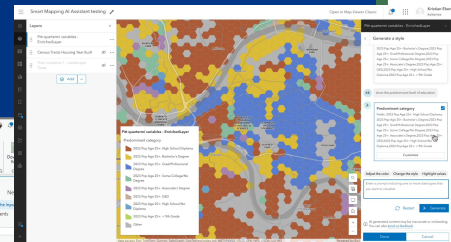
In Beta now

- Survey123 Web Designer
- ArcGIS Business Analyst
- ArcGIS Hub Premium
- ArcGIS for Microsoft Teams

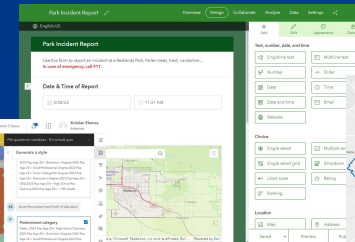
Documentation



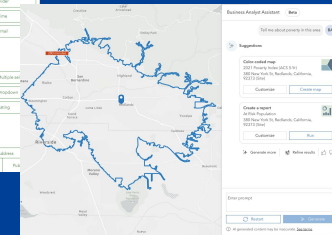
Smart Mapping



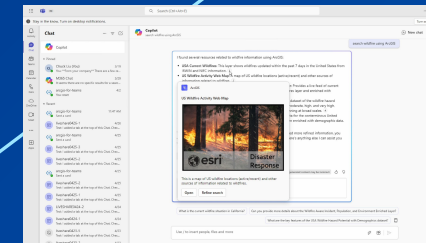
Survey123



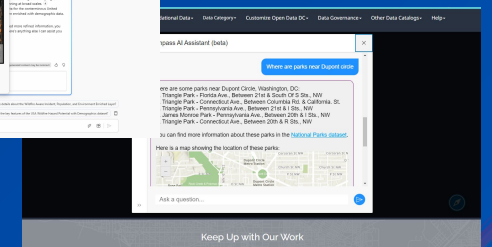
Business Analyst



ArcGIS for Microsoft Teams



Hub



ArcGIS

Empowering GIS Professionals

Boosting Productivity

Making GIS Easier

Streamline your work and make GIS easier for everyone

Survey 123 AI Assistant

Using generative AI to help you create your survey


STATUS: In Beta testing


About the Survey123 Assistant ✕


The Survey123 assistant is disabled in your organization. This feature must be enabled by an administrator in the Survey123 organization settings. [Learn more about the assistant](#)

The Survey123 assistant uses a large language model (LLM) to help you design surveys from a human-like conversation.

[Got it](#)

 Survey123 assistant **BETA**

I want to include a list of common California tree species in question 3 

 Certainly! Here's an updated version of the sample survey with a list of common California tree species for question 3:

1. Location: Please provide the location of the hazardous tree. You can either use the interactive map to pinpoint the location or enter the full address in the textbox below.
2. Photo: Please upload a photo of the hazardous tree. This will help us assess the situation more accurately.
3. Tree Species: Please select the species of the hazardous tree from the list below:
 - Oak
 - Redwood
 - Pine
 - Eucalyptus
 - Palm
 - Cypress
 - Maple
 - Sycamore
 - Other (please specify)
4. Risk Assessment: On a scale of 1 to 5, with 1 being low risk and 5 being high risk, please rate the potential danger posed by the hazardous tree.

Thank you for taking the time to report a hazardous tree in the City of Redlands. Your input will help us ensure the safety of our community.

[Generate](#)

Send a message

Using AI to describe your imagery

Use your spatial data to prompt to prompt a large language-and-vision assistant (LLaVA)

Geoprocessing

Interrogate Imagery with GeoPrompts

Parameters Environments

Input Raster
Merged_All_Reality-Orthomosaic.tiff

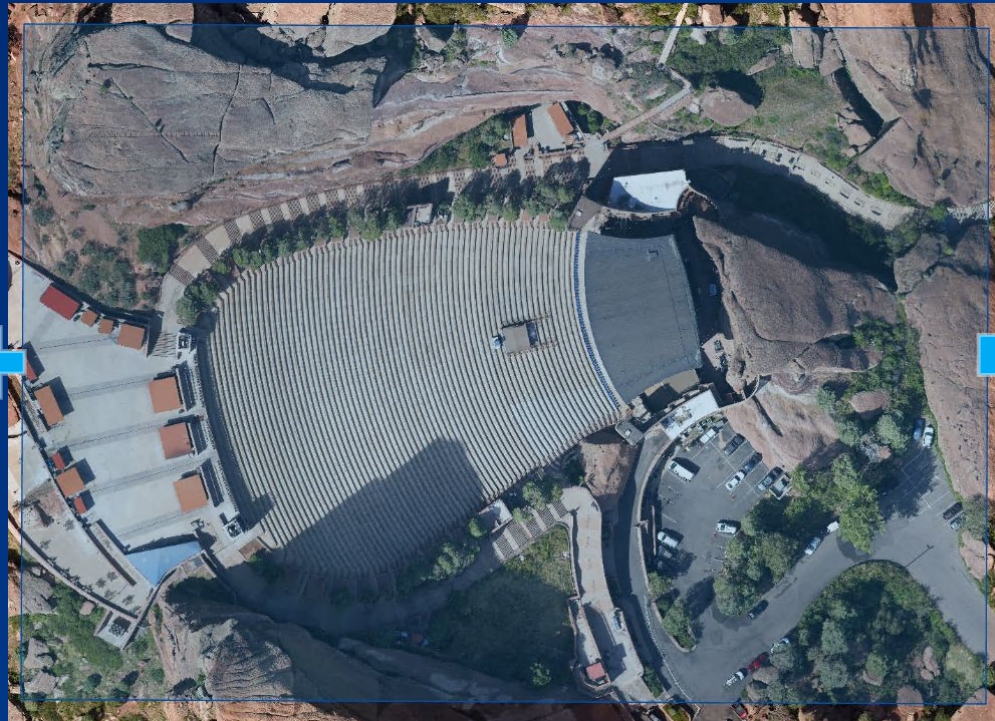
Features to Interrogate
AOI

Query Prompt
Concisely describe what is in the image.

Max Tokens 30

Quantization
Native

Output
AOI_Description



AOI_Description - <Null>

OBJECTID	1
Name	<Null>
Text	<Null>
Integer Value	<Null>
Double Value	<Null>
Date Time	<Null>
ORIG_FID	1
Shape_Length	712.681996
Shape_Area	30763.165604
interrogate_results	The image shows an aerial view of a large outdoor amphitheater, which is situated in a desert-like area

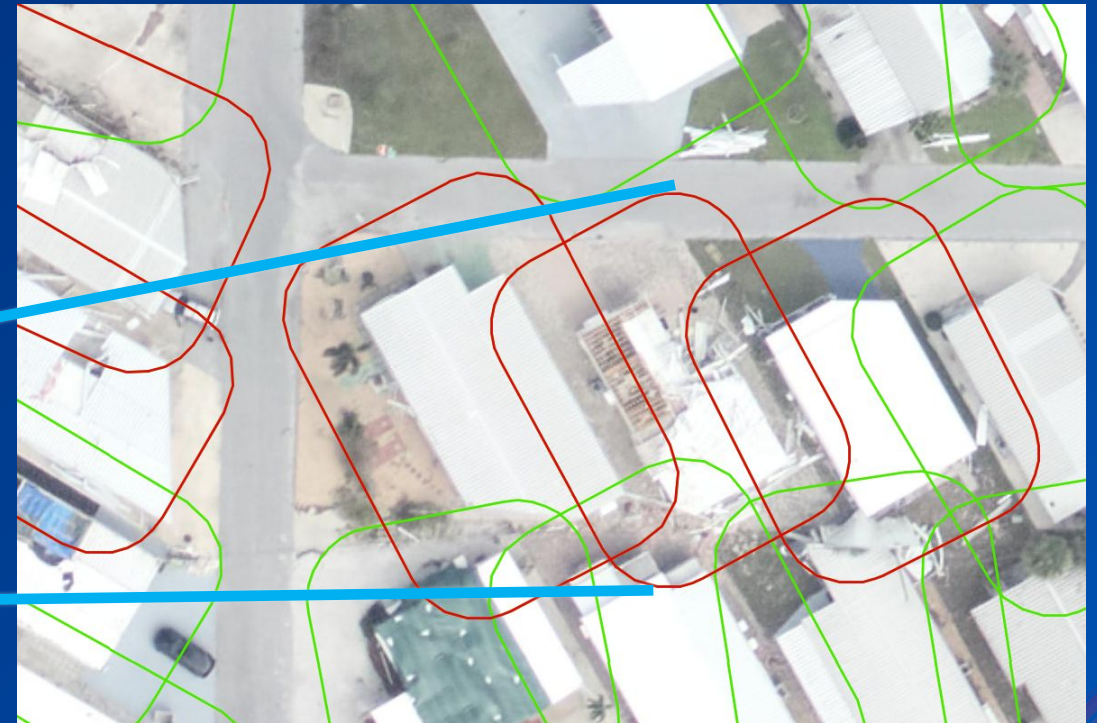
Concisely describe what is in this image.

The image shows an aerial view of a large outdoor amphitheater, which is situated in a desert-like area

Using llava-llama-3-8b-v1_1-transformers

Using a LLaVA to assess storm damage

Using AI to generate descriptions of homes and parcels

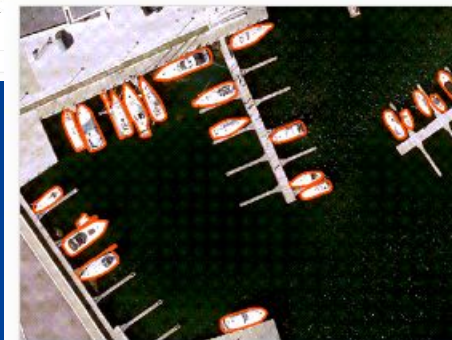
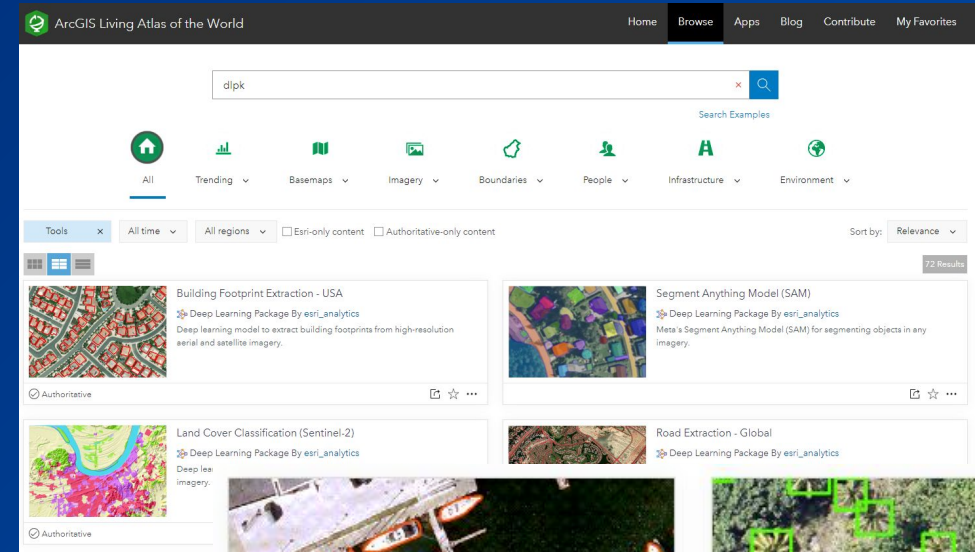


interrogate_results

The image shows a construction site with a partially completed building, a pile of rubble, and a crane

Conclusions

- AI appearing across GIS
- Many entry points into AI for you
- Full implications of impact of AI on GIS is still undetermined
- Don't assume



TUTORIAL

Detect objects with Text SAM

Use a multi-purpose GeoAI model with a free-form language prompt to detect boats in Copenhagen imagery.



TUTORIAL

Detect objects with a deep learning pretrained model

Use a GeoAI tool and a pretrained model to automate palm tree detection.

Looking for more information?

AI + Location Intelligence

Organizations are pairing location intelligence with AI to automate tasks, make accurate business predictions, and gain insights from large amounts of data.



An opportunity

Offering \$1M in AWS credits



A GRAND CHALLENGE FOR GENERATIVE AI AND GEOSPATIAL TECHNOLOGY

Join Amazon Web Services (AWS) and the Taylor Geospatial Institute (TGI) on October 29th in St. Louis to kick off a Generative AI for Geospatial Challenge.

AWS and TGI are sponsoring a Generative AI for Geospatial Challenge that will bring together scientists, innovators, industry leaders, and the largest cloud resources to explore and expand the art of the possible for big-impact applications using geospatial data. Learn about the challenge, and join us for this first of its kind event focusing on the power of cloud computing and geospatial information.

<https://taylorgeospatial.org/awschallenge/>



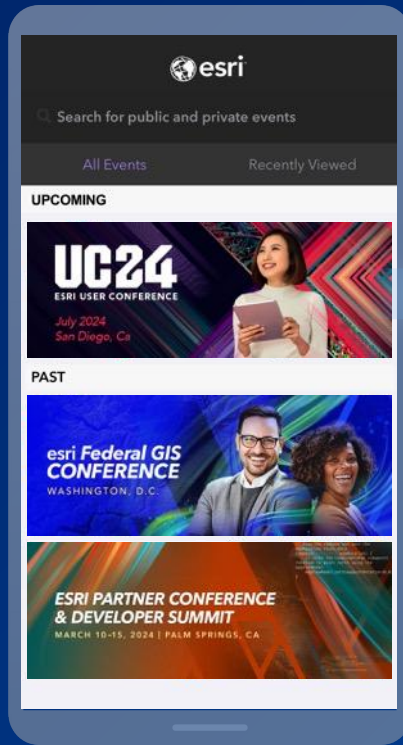
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SCIENCE
OF
WHERE**[®]

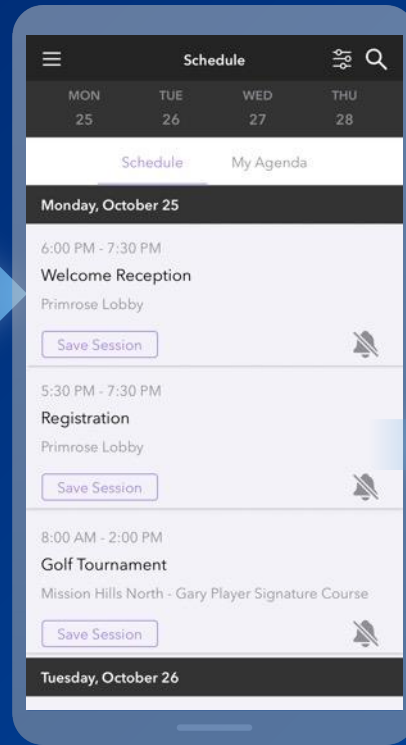
Copyright © 2024 Esri. All rights reserved.

Please Share Your Feedback in the App

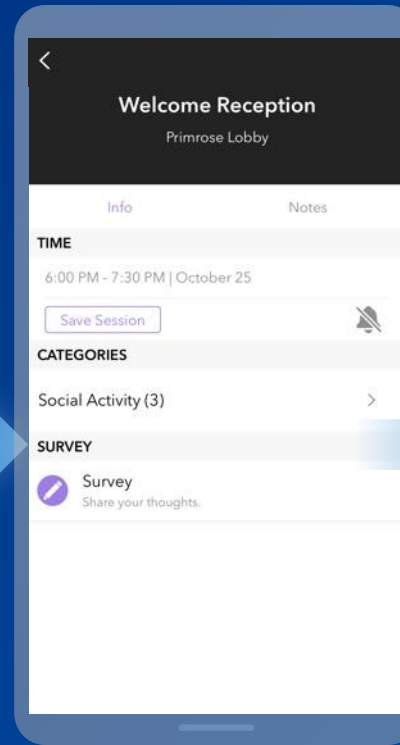
Download the Esri Events app and find your event



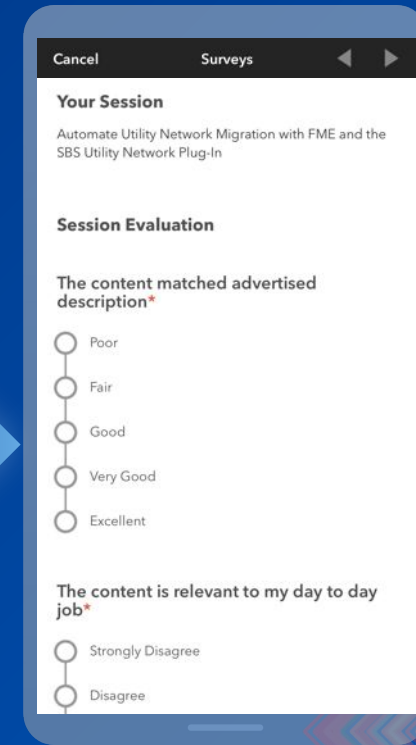
Select the session you attended



Scroll down to "Survey"



Log in to access the survey





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