An Introduction to the GeoAI Python Package: Bridging AI and Geospatial Analysis

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Slides: https://tinyurl.com/geoai-talk

slides

Outline

- Open Geospatial Solutions
- Introduction to GeoAI
- Key Features
  - Data Download
  - Data Visualization
  - Data Preparation
  - Model Training
  - Model Inference
  - Post-processing
- Applications
  - buildings, cars, ships, solar panels, wetlands, waters, land cover classification
- Additional Resources
- Q&A

Open Geospatial Solutions

https://github.com/opengeos

Open Geospatial Solutions

A collection of open-source software packages for the geospatial community

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https://www.facebook.com/groups/... | opengeos@outlook.com

Python Packages

- geemap
- geoai
- geospatial
- geospatial-ml
- HyperCoast
- leafmap
- lidar
- mapwidget
- open-buildings
- pygis
- segment-geospatial
- whitebox-python
- whiteboxgui

Data Catalogs

- geospatial-data-catalogs
- aws-open-data
- aws-open-data-geo
- aws-open-data-stac
- Earth-Engine-Catalog
- NASA-CMR-STAC
- NASA-Earth-Data
- stac-index-catalogs
- maxar-open-data
- datasets
- data
- ee-tile-layers

ArcGIS Toolboxes

- WhiteboxTools-ArcGIS

Web Apps

- streamlit-geospatial
- streamlit-map-template
- solara-geemap
- solara-geospatial
- solara-template
- solara-maxar
- voila-geospatial
- geospatial-dataviz
- surface-water-app

R Packages

- whiteboxR

Useful Resources

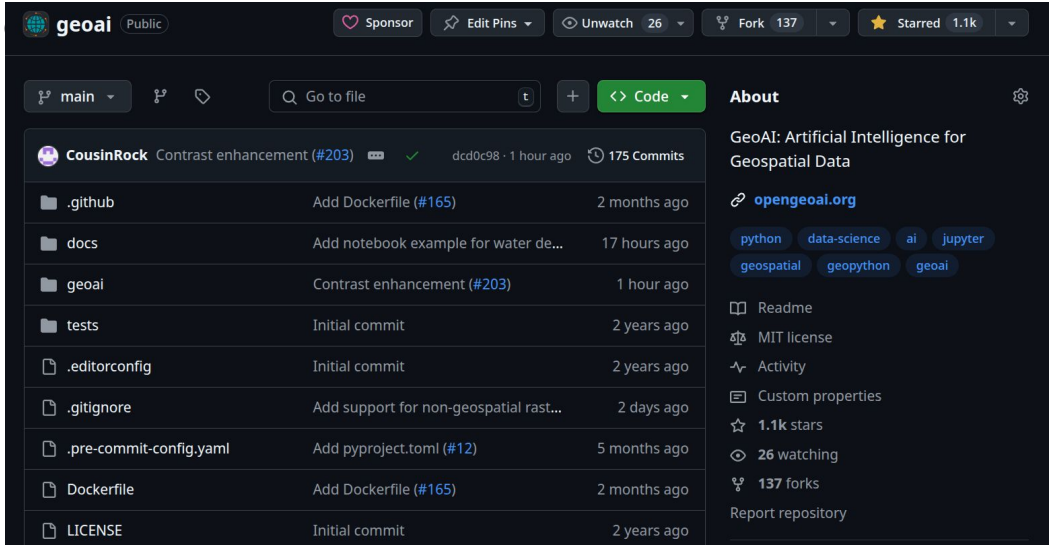
- Awesome-GEE
- python-geospatial

https://github.com/opengeos

Introduction to GeoAI

Introduction to the GeoAI Python Package

- A powerful Python package for integrating Artificial Intelligence with geospatial data analysis and visualization
- GitHub: https://github.com/opengeos/geoai



Installation

https://opengeoai.org/installation

- pip
  - pip install geoai-py
- conda/mamba
  - mamba install -c conda-forge geoai
- uv
  - uv pip install geoai-py

- GPU support
  - mamba install -c conda-forge geoai "pytorch=*=cuda*"

Key Features

Data Download

- Search and download data from SpatioTemporal Asset Catalogs, including Microsoft Planetary Computer
- Search and download data from Overture Maps, including buildings, roads, and places

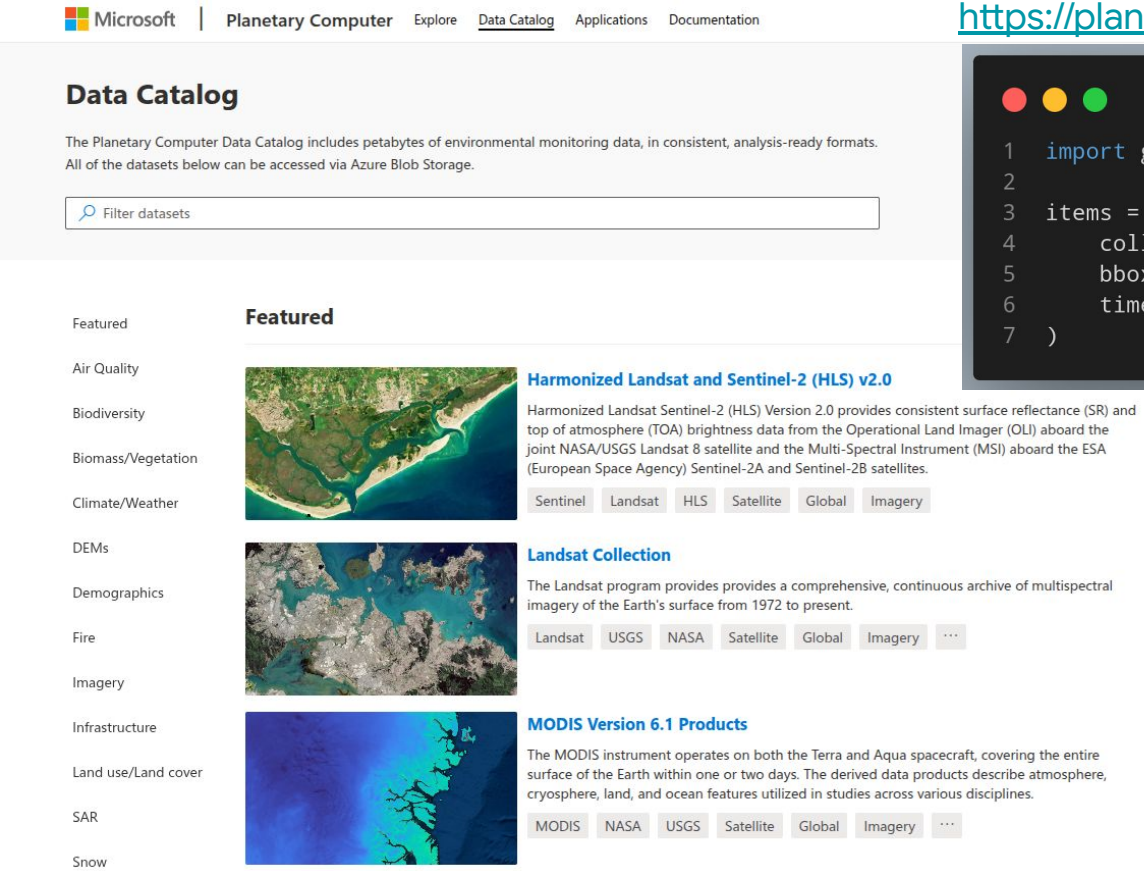
```python
import geoai

bbox = (-117.6029, 47.65, -117.5936, 47.6563)
geoai.download_naip(
    bbox=bbox,
    output_dir="naip_data",
)
geoai.download_overture_buildings(
    bbox=bbox,
    output="buildings.geojson",
)
```

notebook

Microsoft Planetary Computer

https://planetarycomputer.microsoft.com/catalog

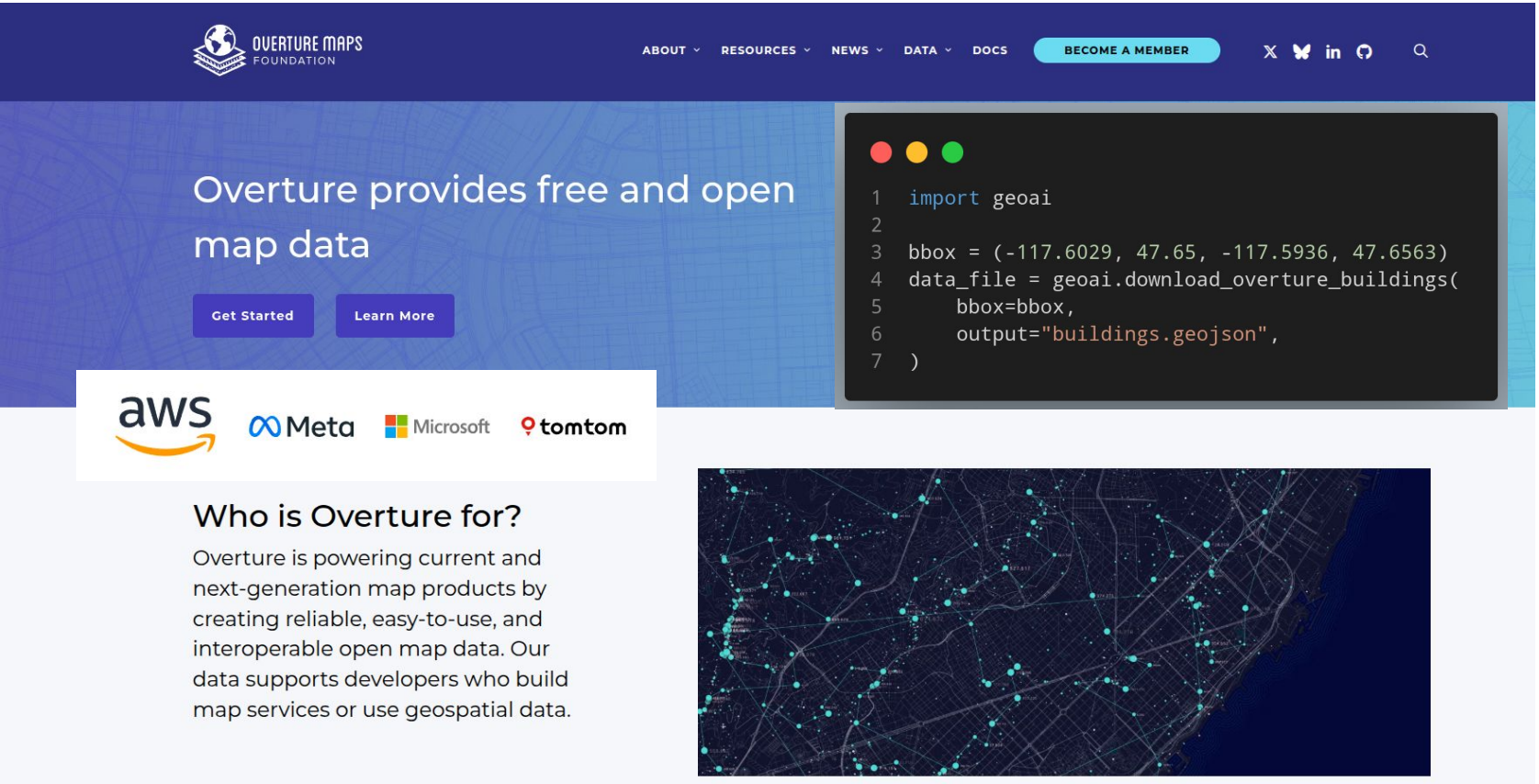



```python
import geoai

items = geoai.pc_stac_search(
    collection="naip",
    bbox=[-76.6657, 39.2648, -76.6478, 39.2724],
    time_range="2013-01-01/2014-12-31",
)
```

Overture Maps

https://overturemaps.org

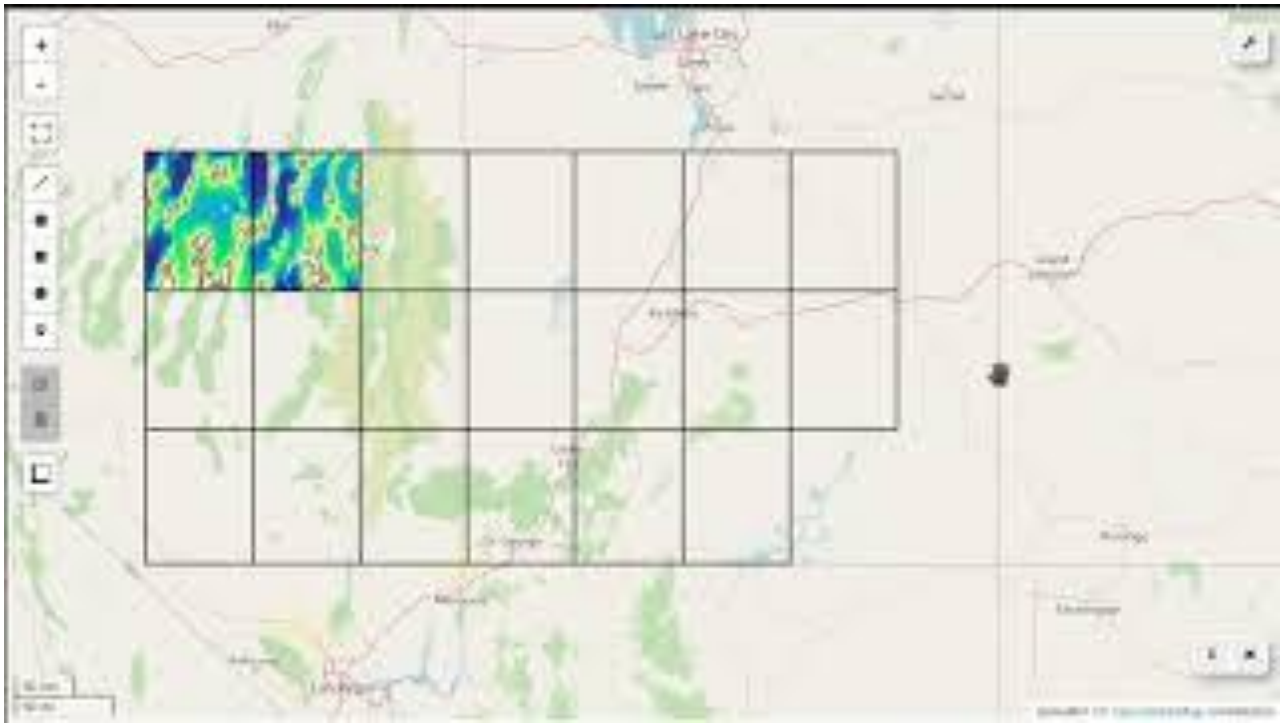


Data Visualization - Planetary Computer

notebook

- Search and visualize data from Planetary Computer

```
1  import geoai
2
3  m = geoai.Map()
4  m
```



Data Visualization - 3D Globe

notebook

- Visualize geospatial data on a 3D globe

```python
import geoai

m = geoai.MapLibre(
    center=[-100, 40],
    zoom=3,
    style="liberty"
    )
m.add_overture_3d_buildings()
m.add_globe_control()
m

```

Data Preparation - Create Vector Data

notebook

- Create vector data interactively

```python
import geoai

m = geoai.MapLibre(style="liberty")
m.add_draw_control()
properties = {
    "Type": ["Residential", "Commercial"],
    "Area": 3000,
    "Name": "Building",
    "City": "Seattle",
}
widget = geoai.create_vector_data(m, properties)
widget

```

Data Preparation - Edit Vector Data

- Edit vector data interactively

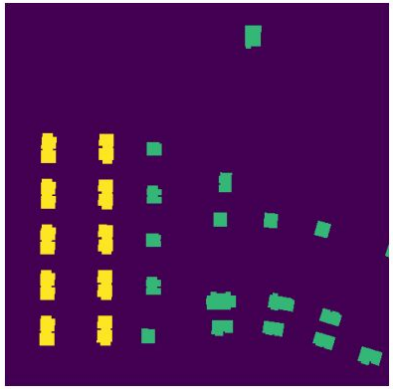
notebook

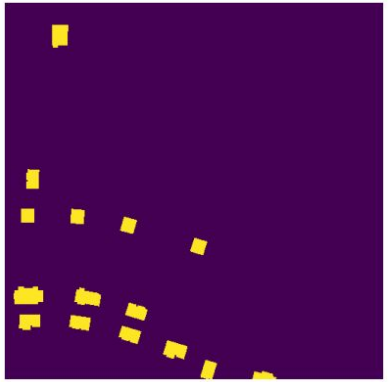
```python
import geoai

m = geoai.MapLibre(style="liberty")
url = "/path/to/your/geojson/file.geojson"
props = {
    "class": ["apartments", "terrace", "house"],
    "height": 0.0,
}
widget = geoai.edit_vector_data(m, url, properties=props)
m.add_layer_control()
widget
```

Data Preparation - Create Image Chips

notebook



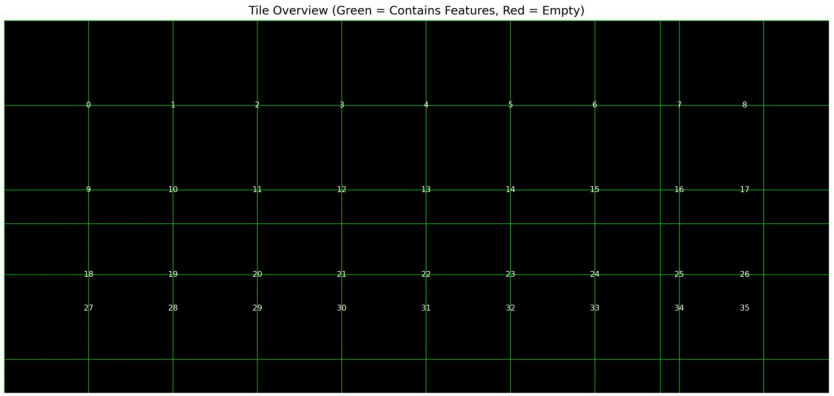


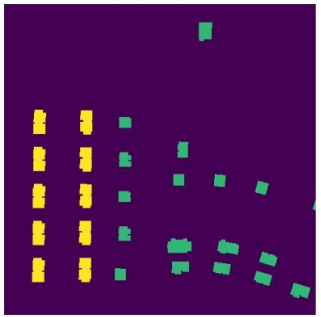
Data Preparation - Create Image Chips

notebook

```python
import geoai

raster_path = "/path/to/image.tif"
vector_path = "/path/to/vector.geojson"
tiles = geoai.export_geotiff_tiles(
    in_raster=raster_path,
    out_folder="output",
    in_class_data=vector_path,
    tile_size=512,
    stride=256,
    buffer_radius=0,
    create_overview=True,
)
```





Model Training

```python
import geoai

raster_path = "/path/to/image.tif"
vector_path = "/path/to/vector.geojson"

out_folder = "output"
tiles = geoai.export_geotiff_tiles(
    in_raster=raster_path,
    out_folder=out_folder,
    in_class_data=vector_path,
    tile_size=512,
    stride=256,
    buffer_radius=0,
)
geoai.train_MaskRCNN_model(
    images_dir=f"{out_folder}/images",
    labels_dir=f"{out_folder}/labels",
    output_dir=f"{out_folder}/models",
    num_channels=4,
    pretrained=True,
    batch_size=4,
    num_epochs=10,
    learning_rate=0.005,
    val_split=0.2,
)
```

notebook

Model Inference

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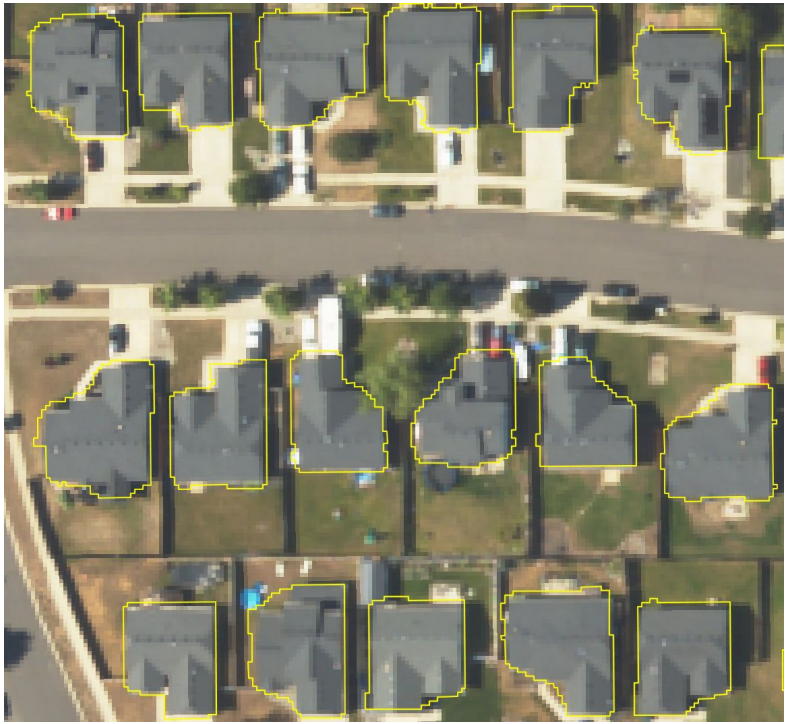
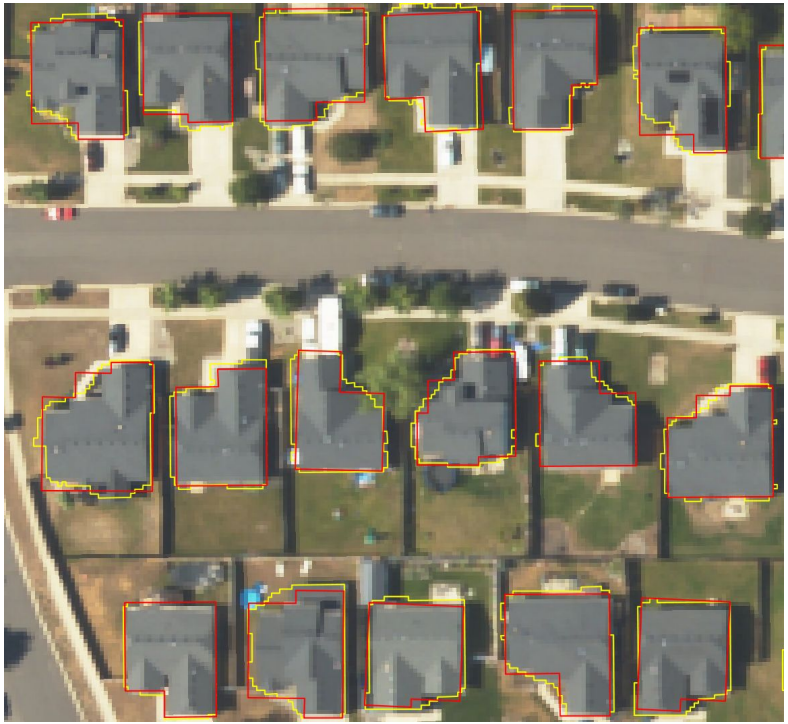
```python
import geoai

test_raster_path = "/path/to/test_image.tif"
out_folder = "output"
masks_path = "naip_test_prediction.tif"
model_path = f"{out_folder}/models/best_model.pth"
geoai.object_detection(
    test_raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=4,
)
```



Post-processing - Regularization

notebook

```python
import geoai

vector_path = "/path/to/vector/file.geojson"
gdf = geoai.regularize(
    data=vector_path,
    simplify_tolerance=2.0,
    allow_45_degree=True,
    diagonal_threshold_reduction=30,
    allow_circles=True,
    circle_threshold=0.9,
)
```



Post-processing - Regularization

notebook

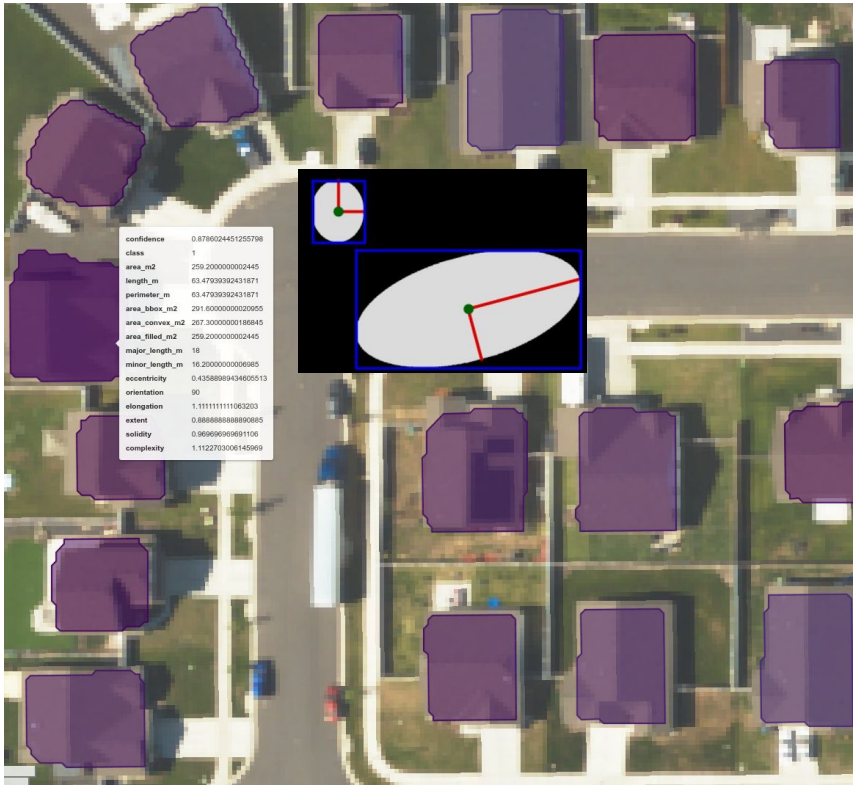
- Regularize building footprints

Post-processing - Geometric Properties

notebook

- Calculate geometric properties

```python
import geoai

vector_path = "/path/to/vector/file.geojson"
gdf_props = geoai.add_geometric_properties(
    data=vector_path,
    area_unit="m2",
    length_unit="m"
    )
gdf_props.head()
```



Applications

Building Footprint Extraction

notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = f"building_footprints_usa.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)
```

Solar Panel Extraction

notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = "solar_panel_detection.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)
```

Car Detection

notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = "car_detection_usa.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)

```

Ship Detection

notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = "ship_detection.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)
```

Surface Water Mapping

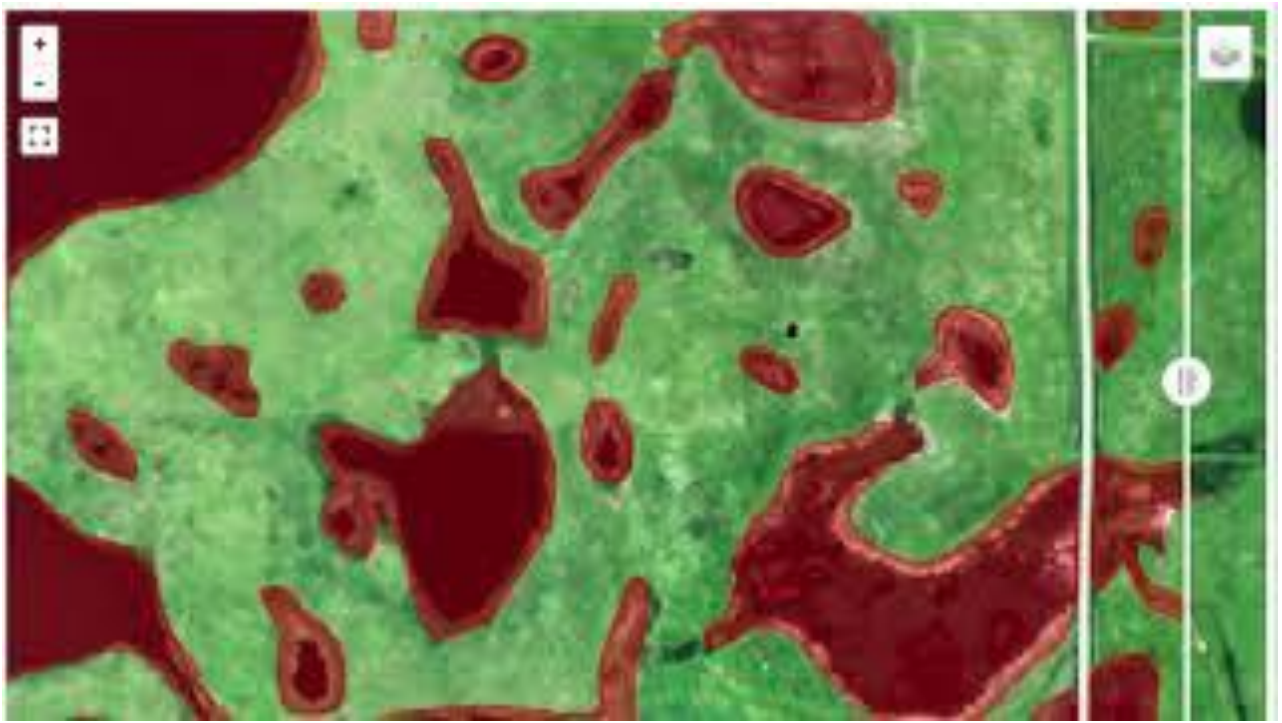
notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = "water_detection.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)
```

Wetland Mapping

notebook

```python
import geoai

raster_path = "/path/to/your/image.tif"
masks_path = "prediction.tif"
model_path = "wetland_detection.pth"
geoai.object_detection(
    raster_path,
    masks_path,
    model_path,
    window_size=512,
    overlap=256,
    confidence_threshold=0.5,
    batch_size=4,
    num_channels=3,
)

```



Land Cover Classification

notebook

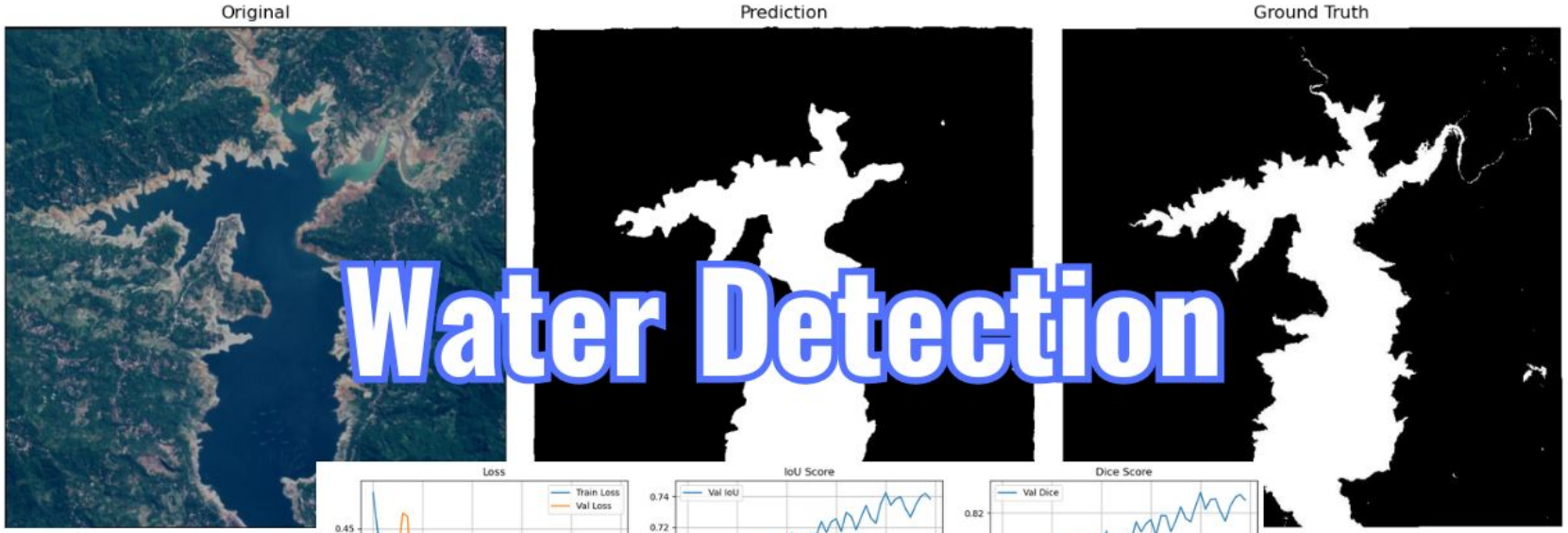
```python
import geoai

geoai.semantic_segmentation(
    input_path=test_raster_path,
    output_path=masks_path,
    model_path=model_path,
    architecture="unet",
    encoder_name="resnet34",
    num_channels=4,
    num_classes=13,
    window_size=512,
    overlap=256,
    batch_size=4,
)
```

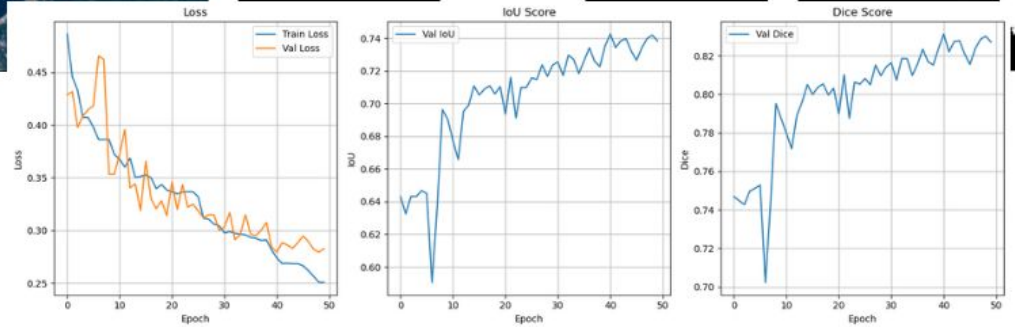
Create Image Chips from Multiple Images and Masks

notebook

Using Non-geospatial Raster Formats (JPG/PNG)

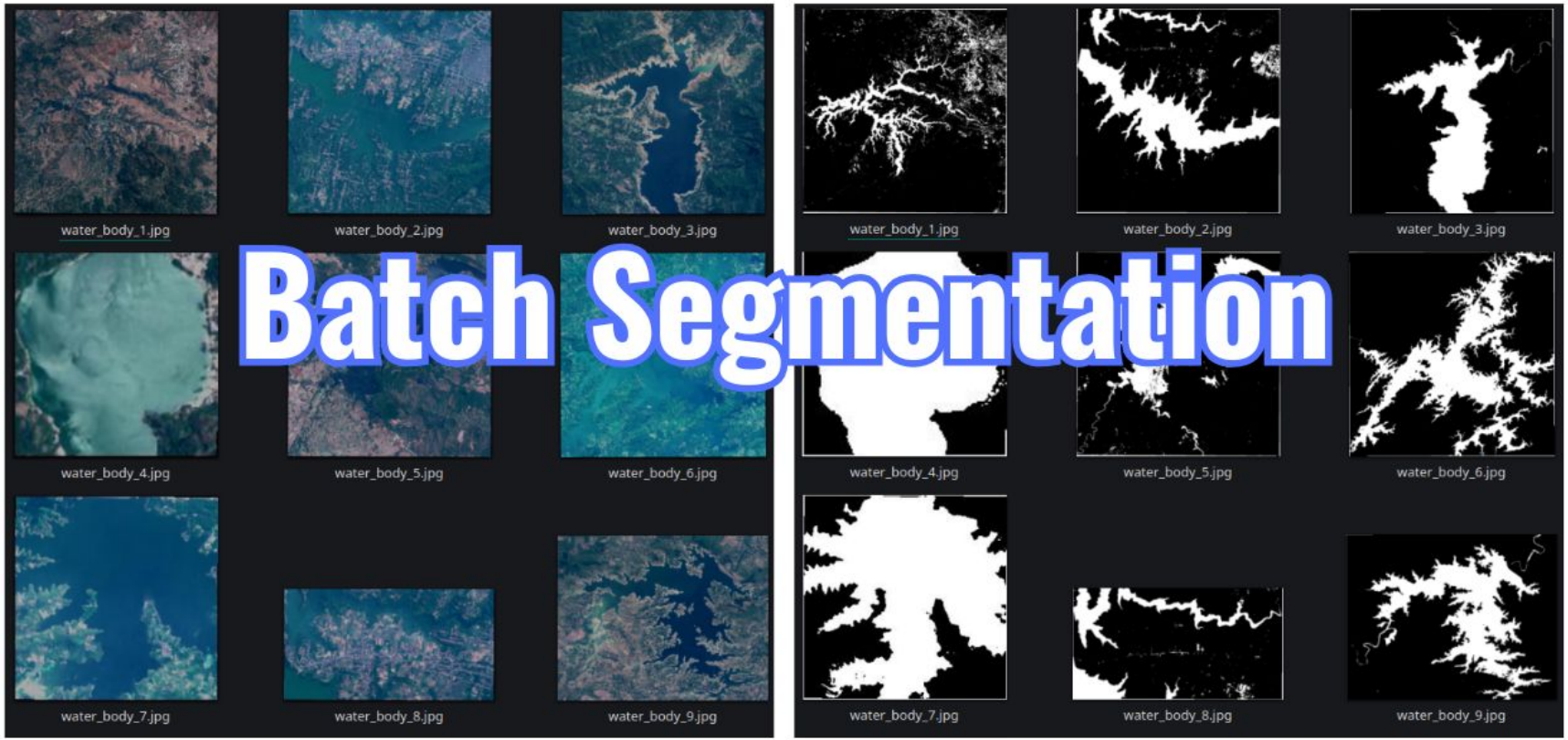
notebook





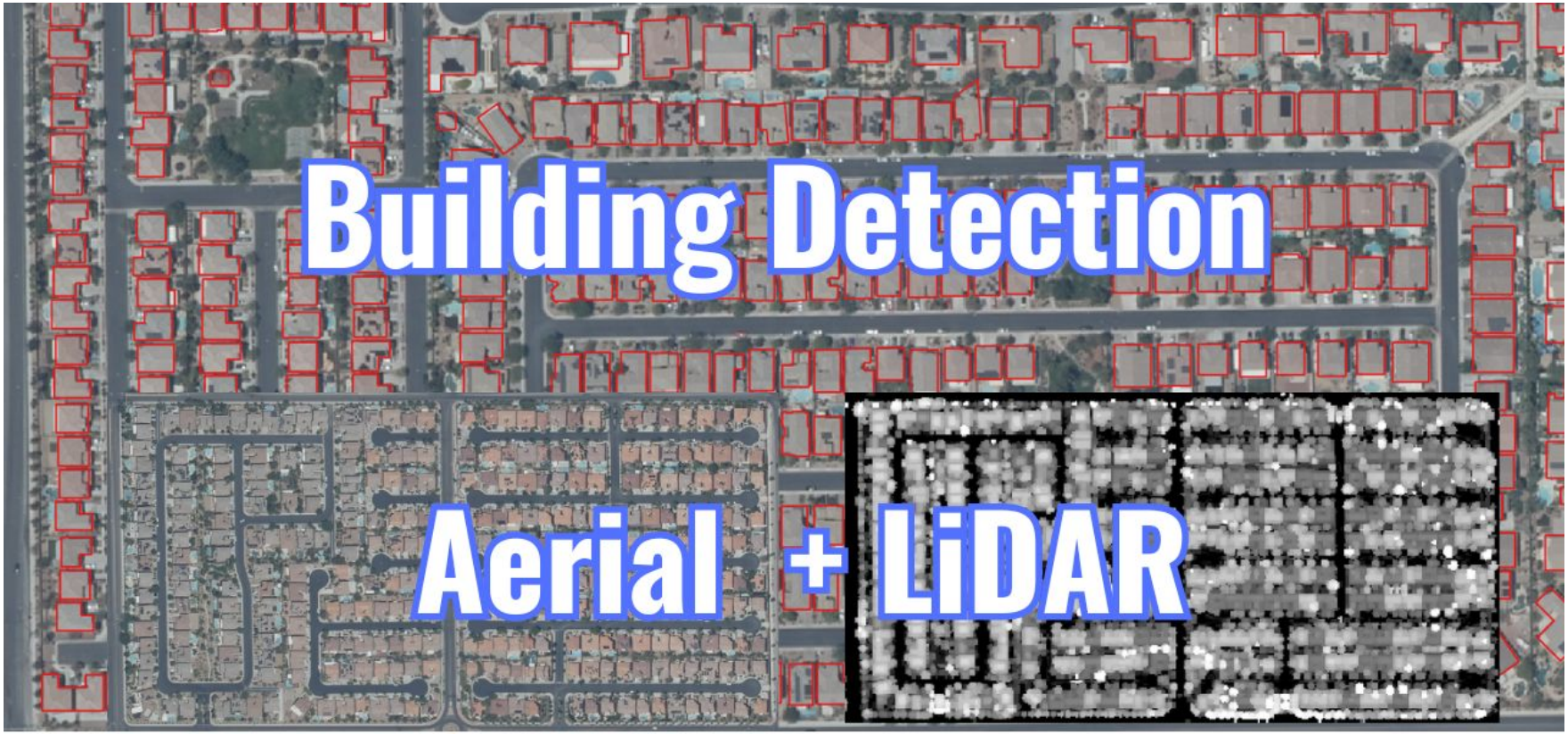
Batch Segmentation on Multiple Satellite Images

notebook



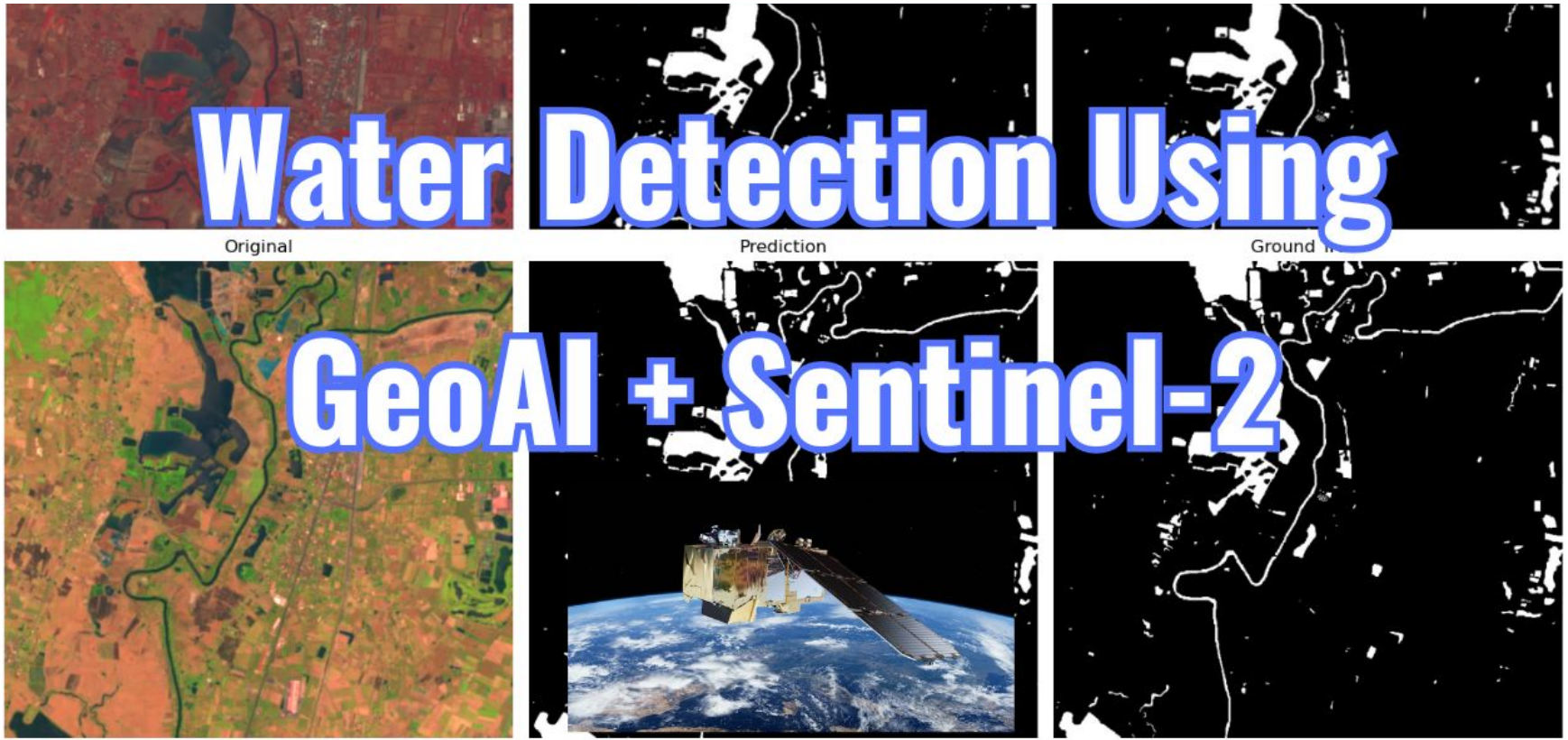
Building Detection with Aerial Imagery and LiDAR

notebook



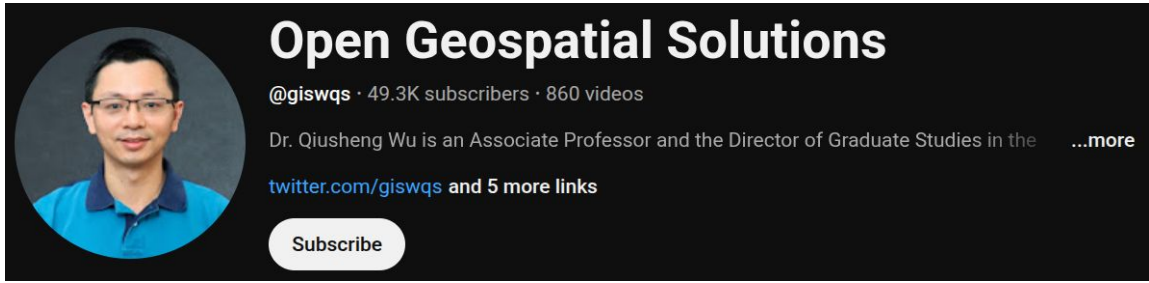
Water Detection Using Sentinel-2 Satellite Imagery

notebook



Additional Resources

YouTube



https://youtube.com/@giswqs

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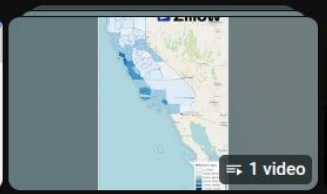

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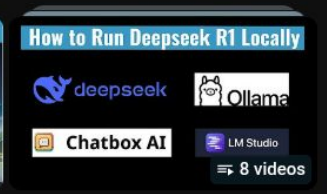

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3D Mapping with MapLibre and Leafmap
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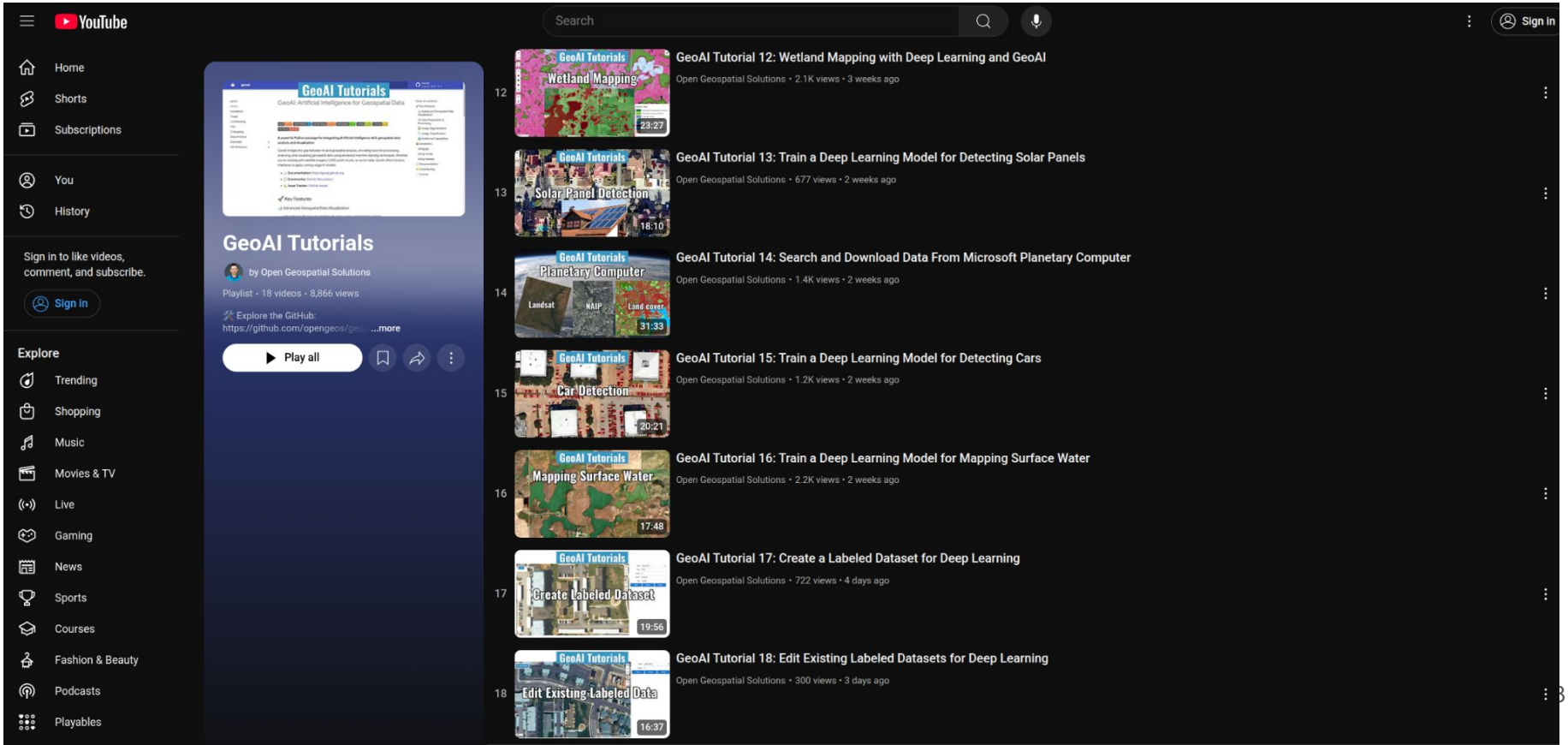
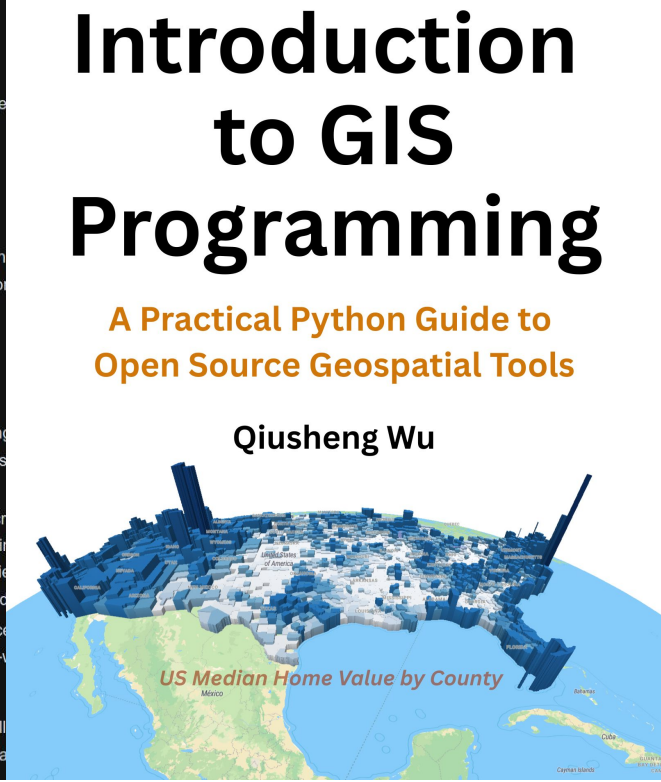
GeoAI Tutorials

https://tinyurl.com/GeoAI-Tutorials



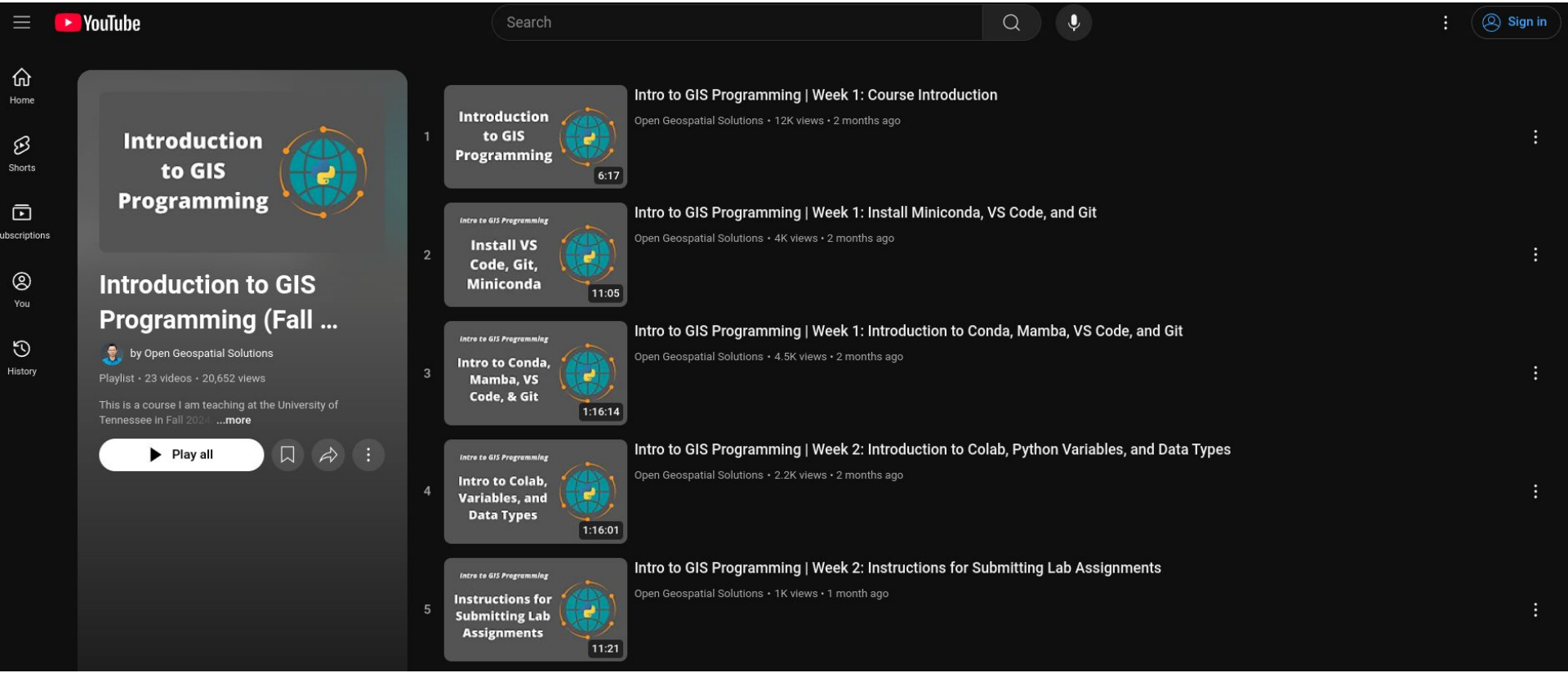
Introduction to GIS Programming

https://gispro.gishub.org/



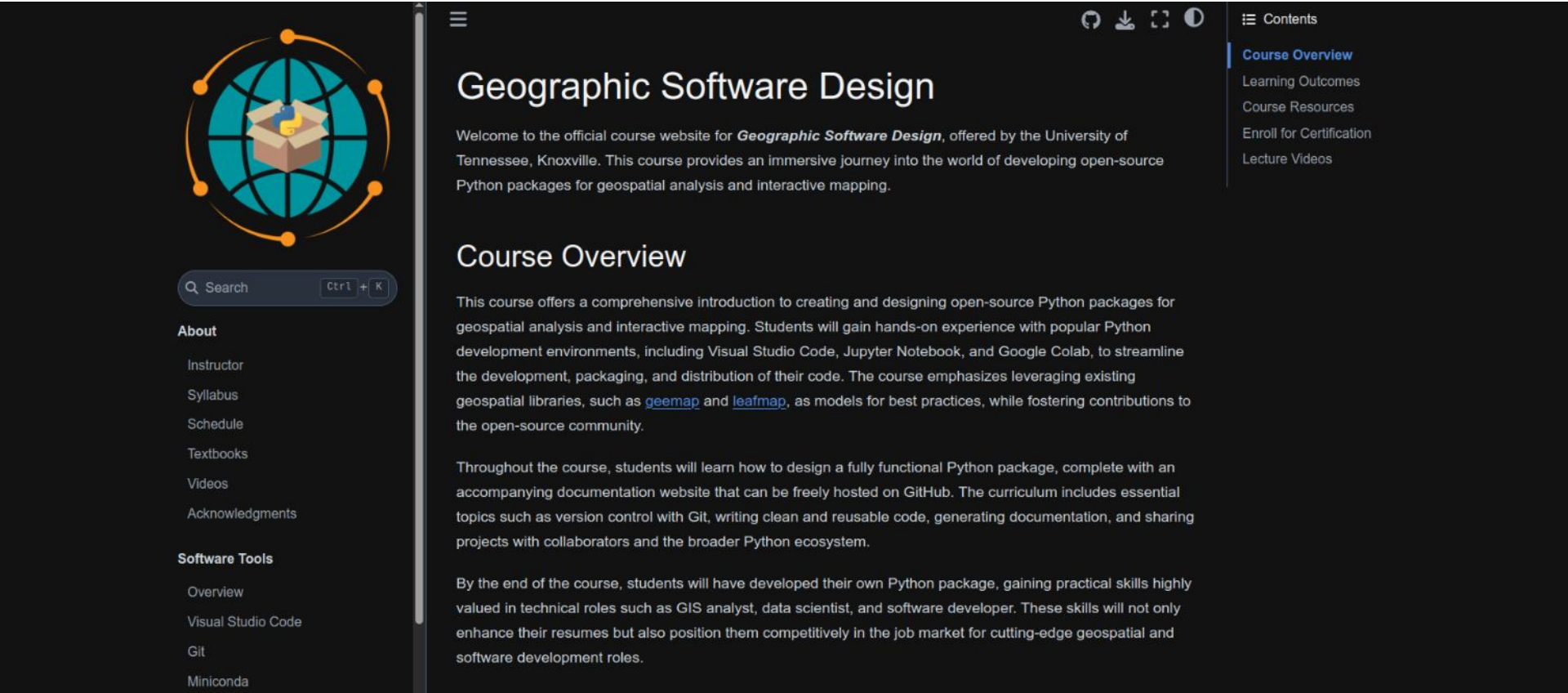
Introduction to GIS Programming

https://bit.ly/intro-gis-programming



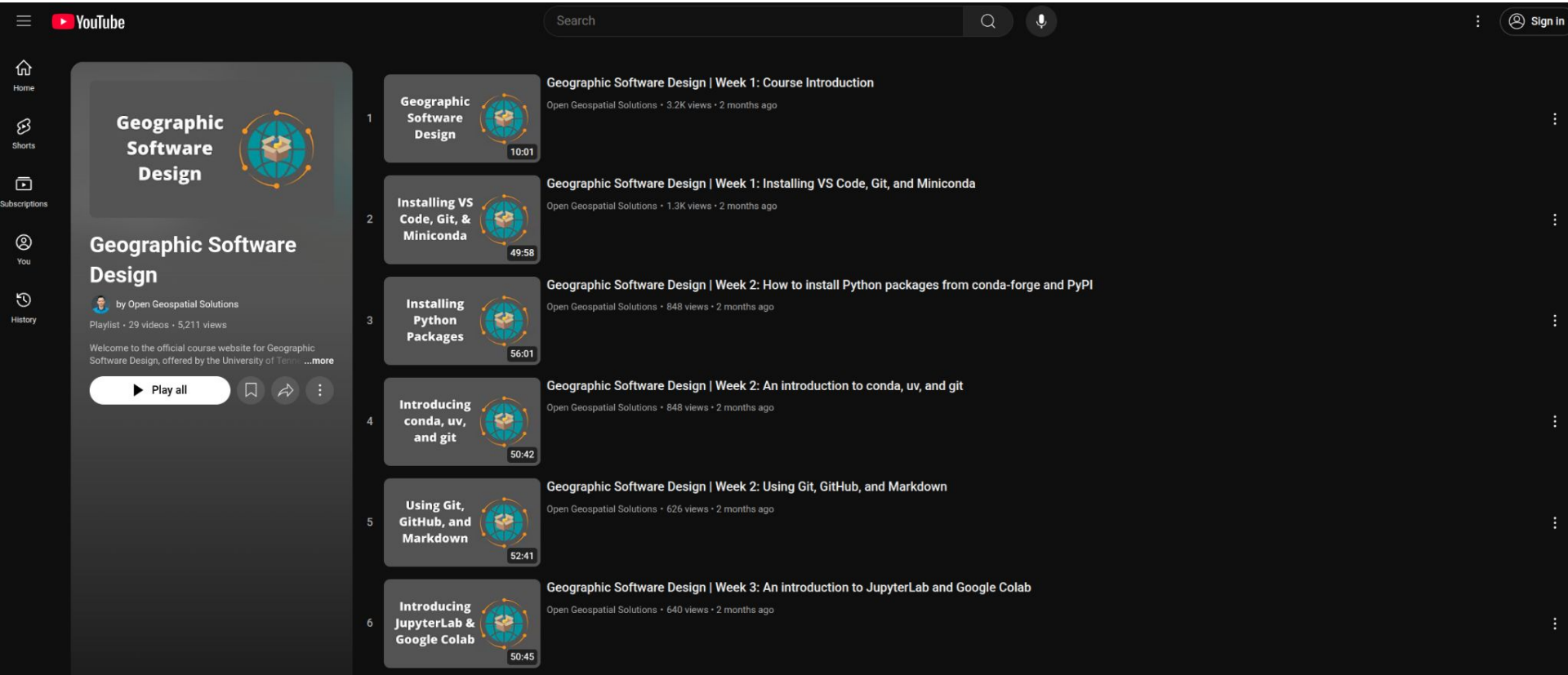
Geographic Software Design

https://geog-510.gishub.org



Geographic Software Design

https://geog-510.gishub.org



Demo

https://opengeoai.org/workshops/GeoAI_Workshop_2025

Thank you!

Any questions

Qiusheng Wu

https://gishub.org