👩‍💻 A Developer's Guide to Open Source Web Mapping Libraries 🗺️

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#WITS24

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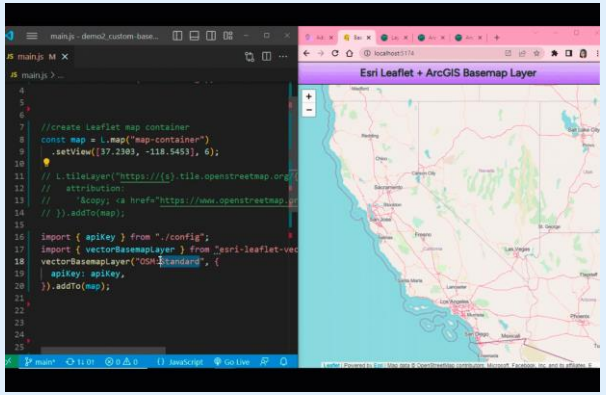

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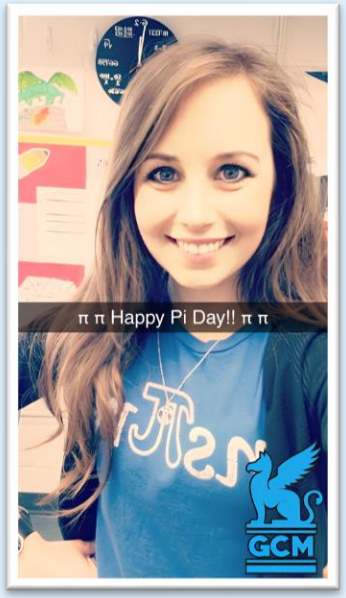


From Teaching to Tech

EAST TENNESSEE STATE UNIVERSITY 1911

PULASKI COUNTY PUBLIC SCHOOLS PATHWAY TO A BRIGHTER TOMORROW

RU RADFORD UNIVERSITY

Fairfax County PUBLIC SCHOOLS ENGAGE • INSPIRE • THRIVE

SheCodes

CF CAREERFOUNDRY

esri THE SCIENCE OF WHERE

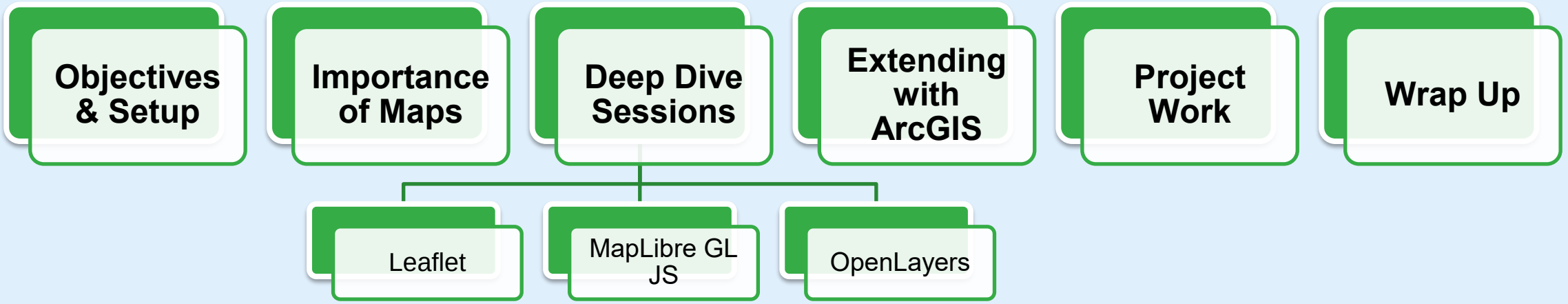
Description & Prerequisites

What to Expect

Join this interactive workshop to master open source web mapping technologies using HTML, CSS, and JavaScript. Ideal for developers, this hands-on session covers everything from selecting suitable libraries (like Leaflet, MapLibre GL JS, and OpenLayers) to understanding core geospatial data concepts. Engage in practical exercises, setting up your environment, and creating interactive maps. Learn best practices, optimization techniques, and explore data visualization and cartographic design to enhance the impact and clarity of your maps. Whether you're new to GIS or seeking to refine your skills, this tutorial offers valuable insights and live demonstrations for building efficient, scalable mapping applications. The session concludes by providing tips on continuous learning and development in the field of open source GIS, equipping attendees with resources and knowledge to further their journey in mapping technology.

Agenda

Workshop Overview



Learning Objectives

What You Will Learn

Create maps for JavaScript apps

Three web mapping libraries

Mapping & GIS concepts

Use cases & examples

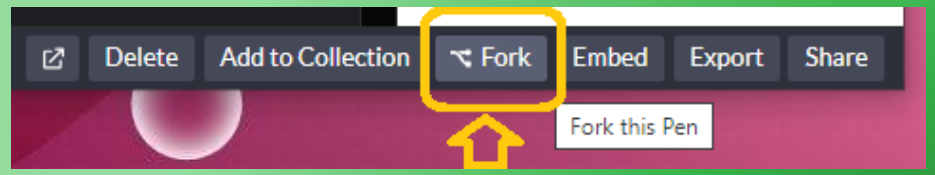
Extending, customizing, & hosting

Starter Code, Solutions, and More

Collection & Repository

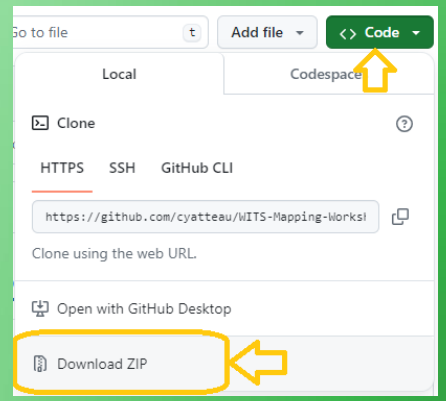
CodePen Collection

- The Collection *(https://codepen.io/collection/vBkLNM)*
- create copies of individual pens by forking



GitHub Repo

- The GitHub Repo *(https://github.com/cyatteau/WITS-Mapping-Workshop-May-2024)*
- download the entire repo



Slides
https://github.com/cyatteau/WITS-Mapping-Workshop-May-2024/blob/main/Slides-Workshop.pdf

Integrated Development Environment

IDE Options

CodePen
Easy to use

Create an account at codepen.io

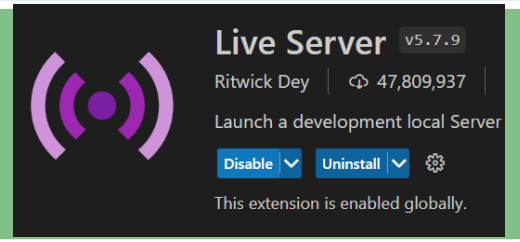
Shortcut: *Shift + Tab*

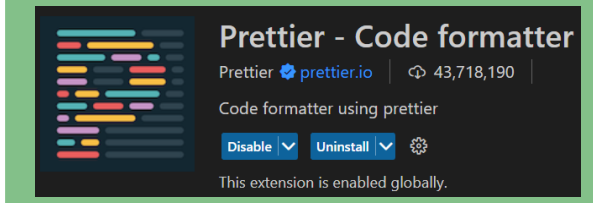
Visual Studio Code
More Powerful

Download at
https://code.visualstudio.com/download

EXTENSIONS

View ➔ Extensions





Shortcut
Alt/Option + Shift + F

The Impact and Ubiquity of Maps

It’s all about Location

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Everyday Mapping

How we all use Maps

- Navigation/Directions
- Social Media
- Travel & Living
- Fitness Apps
- Public Transit
- Weather Radar
- Local Commerce

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Maps in Action

Societal Vitality

- Disaster Response
- Urban Planning
- Public Safety
- Route Optimization
- Wildlife Tracking

CRIMEMAPPING™.com
Helping You Build a Safer Community

RouteXL

MOVEBANK

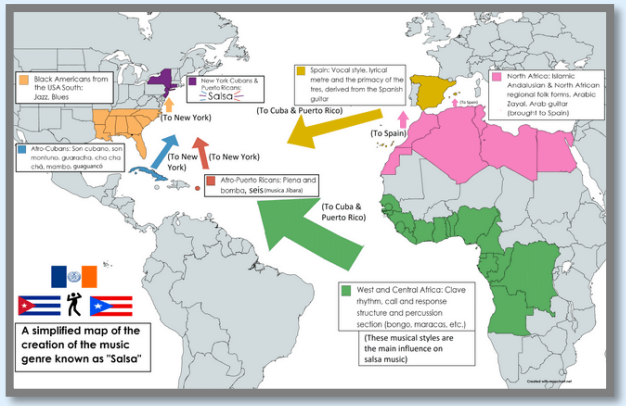
HOT
Humanitarian OpenStreetMap Team

Storytelling with Maps

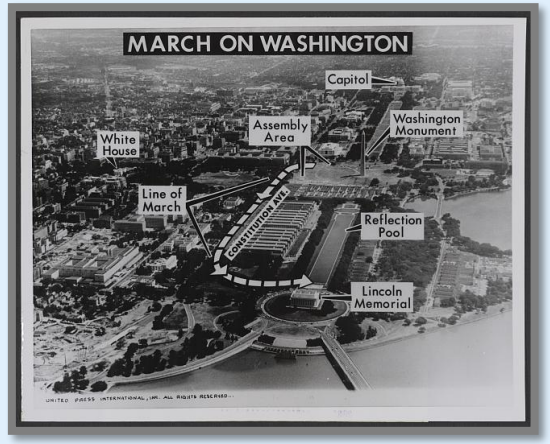
Visual Evidence

- Community Development
- Historical Events
- Cultural Impact
- Voting & Politics
- Outbreaks
- City Growth

The New York Times



Spotify



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Deep Dive Sessions

Three Mapping Libraries – Learn, Code, Create

Exploring the Commonalities

Similarities among Leaflet, MapLibre GL JS, & OpenLayers

💻 Core Tech

- Built on JavaScript
- Compatible with HTML & CSS
- Works across modern browsers

📝 Open Source

- Community-driven
- Modifiable

🧠 Easy to Learn

- Simple APIs
- Extensive documentation

🔑 Key Features

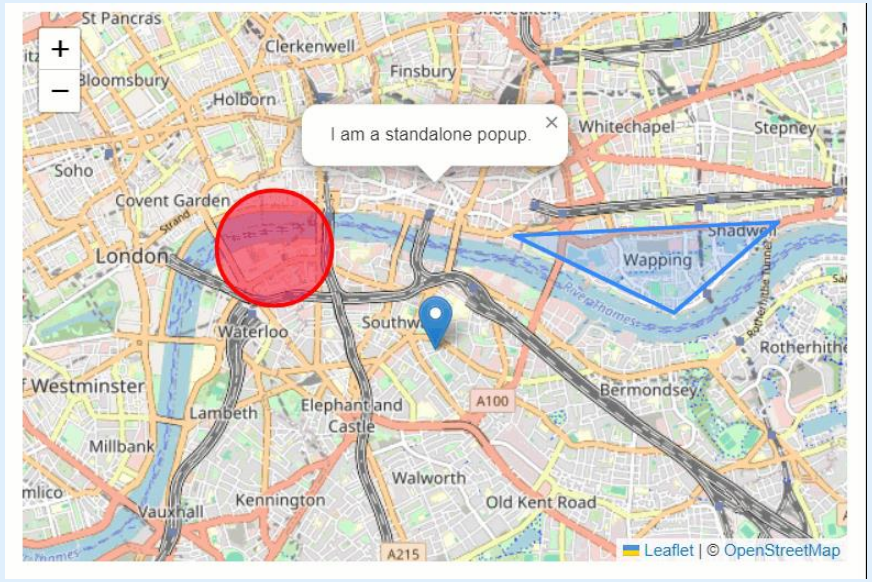
- Interactive & mobile friendly
- Customizable
- Web Mercator projection

leaflet.com

What is Leaflet?

💻 leafletjs.com 🧑‍💻 github.com/Leaflet

- Lightweight (~42 KB JS)
- Tons of plugins: leafletjs.com/plugins
- Focuses on simplicity and performance



Our First Map App!

A Simple Leaflet Website Map

Open the Starter Code for Leaflet

- 👀 **Step 1**: Understand the code
- 🧑‍💻 **Step 2**: Add some code to show the map
- 🖼️ **Step 3**: Examine the image network requests

HINT: *Lost? Find the Solution under "1st Leaflet Map Solution"*

Comment/Uncomment shortcut

CTRL + / or CMD + /

Layer Types

Fundamental components used to display data

- **Raster (Tile) layers**: Basemap images

  Humanitarian OSM Team: https://tile.openstreetmap.fr/hot/{z}/{x}/{y}.png
  CartoDB: https://basemaps.cartocdn.com/light_all/{z}/{x}/{y}{r}.png
  OpenTopoMap: https://tile.opentopomap.org/{z}/{x}/{y}.png

- **Markers**: HTML point icons
- **Vectors**: SVG shapes (lines, circles, polygons)
- **Layer Group**: Group together markers and vectors

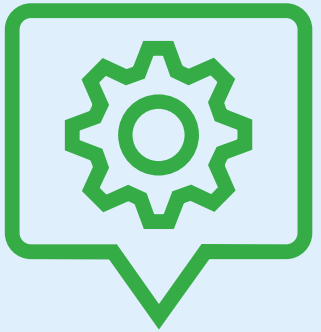
🔎 Latitude/Longitude Finder (Geocoder) 🔎
https://geocode.arcgis.com/arcgis/rest/services/World/GeocodeServer/findAddressCandidates?f=pjson&outFields=*&singleLine=**ADDRESS/PLACE**

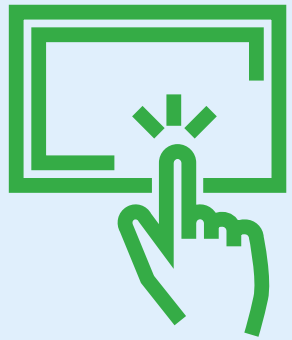
HINT: *Lost? Find the final Solution under "Final Leaflet Map Solution"*

Interactive Features

Handling user interactions

- **Event Handling**
  - Clicks
  - Mouseovers
  - Drags
- **Info Attaching**
  - Popups
  - Tooltips





HINT: *Lost? Find the final Solution under “Final Leaflet Map Solution”*

Extending with Esri Leaflet

developers.arcgis.com/esri-leaflet

- **Esri Leaflet**: Set of tools to use ArcGIS services in Leaflet

  👨‍💻 **GitHub Repo** 📜 **Documentation**

- 🔎 **Esri Leaflet Geosearch:** Auto-complete enabled search
  - 📝 **API Reference**
  - 🪜 **Steps for use**
    - **Step 1:** Add the libraries from CDN
    - **Step 2:** Add the control and set the options
    - **Step 3:** Show searched result
    - ***Extensions:*** *Change options, Change popup info (use console.log to help)*

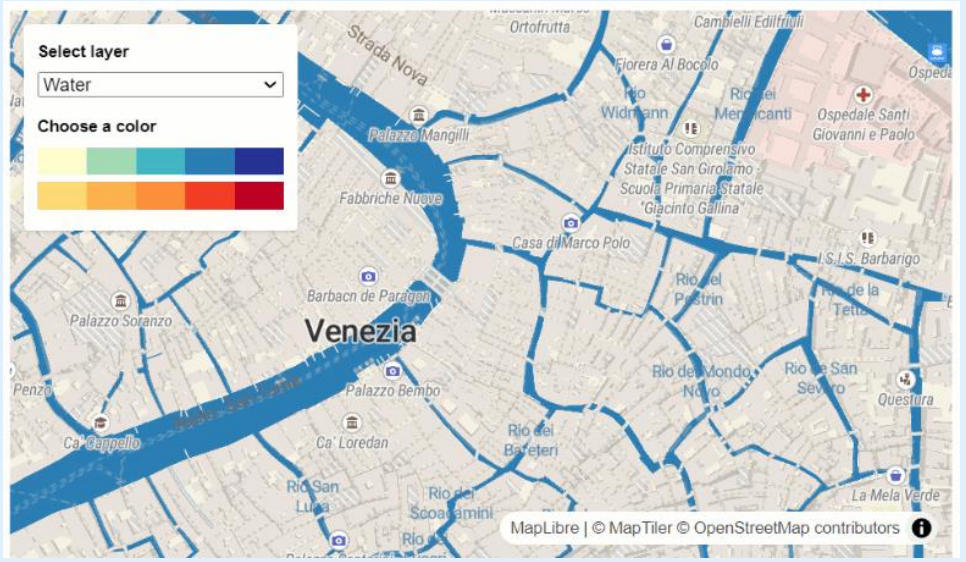
HINT: *Lost? Find the final Solution under "Final Leaflet Map Solution"*

maplibre.org

What is MapLibre GL JS?

maplibre.org github.com/maplibre/maplibre-gl-js

- Developer-led fork of Mapbox GL JS 1.x
- WebGL rendering
- Dynamic data integration
- Customizable styling options



Simple MapLibre GL JS Map

Starter Map

Open the Starter Code for MapLibre GL JS

- 👀 **Step 1**: Understand the code
- 🧑‍💻 **Step 2**: Add some code to show the map
- 🖼️ **Step 3**: Examine the network requests

Comment/Uncomment shortcut

CTRL + / or CMD + /

HINT: *Lost? Find the Solution under "1st MapLibre GL JS Map Solution"*

Vector Tiles

Fundamental components used to display data

- **Vector Tiles:** Compact, client-side WebGL-rendered maps
  - **Dynamic**: On-the-fly & custom styling
  - **Scalable**: Visually clear over all zoom levels
  - **Efficient**: Reduces data size & server load
  - **Data-Driven:** Contain only vector data

- **Vector Tile Examples**
  - **Examples:** - 🔦 MapTiler Bright - 🌞 Jawg Sunny

Note: API keys will expire after today

HINT: *Lost? Find the final Solution under “Final MapLibre GL JS Map Solution”*

Handling Features

Points, Lines, Polygons, and More

- **Markers**: Direct HTML icons
- **Feature Layers**: Grouped data overlaid on a basemap
  - **Hard-coded GeoJSON**: Feature geometry types (lines, polygons)
  - **GeoJSON from a URL:** Server-hosted data

```
https://services.arcgis.com/fLeGjb7u4uXqeF9q/arcgis/rest/services/
  Boundaries_District/FeatureServer/0/query?f=geojson&where=1=1
```

  - ***Extensions:*** *add Popups or query the layer*

HINT: *Lost? Find the final Solution under "Final MapLibre GL JS Map Solution"*

Extending with ArcGIS

developers.arcgis.com/arcgis-rest-js

- **ArcGIS REST JS:** Set of modules for accessing ArcGIS services

  👩‍💻 **GitHub Repo** 📜 **Documentation**

- 🔎 **ArcGIS GeoEnrichment service: Aggregates demographic data**
  - 📝 **API Reference**
  - 🪜 **Steps for use**
    - **Step 1:** Add the libraries from CDN
    - **Step 2:** Use the queryDemographicData function
    - **Step 3:** Handle the results
    - ***Extensions:*** *Get other local facts, change parameters*

HINT: *Lost? Find the final Solution under "Final MapLibre GL JS Map Solution"*

openlayers.org

What is OpenLayers?

💻 openlayers.org 👷 https://github.com/openlayers

- Supports a wide range of map formats
- Advanced geospatial analysis tools
- Excels at managing multiple layers
- Extensive projection support

Simple OpenLayers Map

Starter Map

Open the Starter Code for OpenLayers

- 👀 **Step 1**: Understand the code
- 🧑‍💻 **Step 2**: Add some code to show the map
- 🏞️ **Step 3**: Examine the network requests

HINT: *Lost? Find the Solution under "1st OpenLayers Map Solution"*

Comment/Uncomment shortcut
CTRL + / or CMD + /

Handling Features

Points, Lines, Polygons, and More

- **Simple Data:** No default simple markers, lines, etc. outside of a layer.
- **Feature Layers (aka Vector Layers):** Grouped data that can be in various formats.
  - **Direct Geometry Objects:** `ol.geom.Point`, `ol.geom.LineString`, & `ol.geom.Polygon`
  - **Hard-Coded GeoJSON:** `ol.format.GeoJSON`
  - **GeoJSON from a URL:** Server-hosted data (made using a source)

```
https://services3.arcgis.com/GVgbJbqm8hXASVYi/arcgis/rest/services/philadelphia_pa_schools/FeatureServer/0/query?where=1%3D1&outFields=*&returnGeometry=true&f=geojson
```

```
https://services.arcgis.com/fLeGjb7u4uXqeF9q/arcgis/rest/services/City_Limits/FeatureServer/0/query?where=1%3D1&outFields=*&returnGeometry=true&f=geojson
```

  - ***Extensions:*** *style the Feature Layer* *or* *display a pop-up*

HINT: *Lost? Find the final Solution under "Final OpenLayers GL JS Map Solution"*

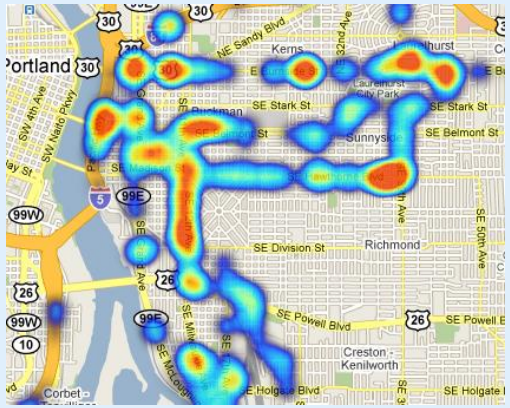
Visualizing Features

Data Visualization

- **Data Visualization**: Graphical representation of data that makes it easier to discover trends. Visualization techniques improves performance and user experience in large datasets.

Clustering: Group objects together to simplify the way the data looks.

Heatmaps: Color-coded visualization showing data density.



HINT: *Lost? Find the final Solution under "Final OpenLayers GL JS Map Solution"*

Other Layer Format Types

WMS and Image Layers

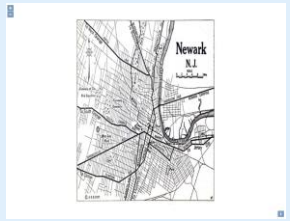
- **Web Map Service (WMS) layers:** Server-side generated dynamic, customizable geospatial images.

USGS National Orthoimagery

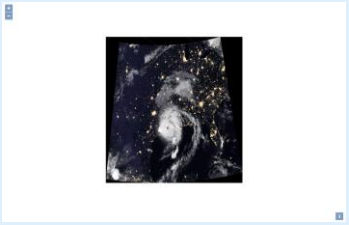
Geoserver Topographic States

- **Image layers:** A single image over a specific extent. These could be aerial, historical, satellite, etc.

Historical Newark, NJ Map from 1922



Aug 2020 – Hurricane Laura Satellite Image



HINT: *Lost? Find the final Solution under "Final OpenLayers Map Solution"*

Overlapping Layers

Stacking Multiple Layers

- **Benefits**
  - Combines diverse datasets for insights
  - Interactive control through opacity adjusting & layer toggling
- **Applications**
  - **Urban Planning:** Integrates zoning, infrastructure, and demographic data.
  - **Environmental Monitoring:** Compares historical and real-time ecological data.
- **Example**
  - **Satellite Imagery on top of OSM:** codepen.io/cyatteau/pen/LYvoNQp

HINT: *Lost? Find the final Solution under "Final OpenLayers Map Solution"*

Utilizing ArcGIS

Display a custom basemap style using the VTSE

- **ArcGIS Vector Tile Style Editor (VTSE)**
  - Create customize vector tile maps - change colors, styles, and visibility.
- **Key Features**
  - Real-time adjustments with live previews.
  - Accessible customization through a user-friendly interface.
- **Getting Started**
  - Requires a free ArcGIS developer account
  - Accessed through the ArcGIS developer portal
  - Use with OpenLayers: `olms.apply(map, basemapURL)` and it's associated CDN library

HINT: *Lost? Find the final Solution under "Final OpenLayers GL JS Map Solution"*

Custom Projects

Individual or group activity

Host Your App with netlify

Share your app with a URL

What is Netlify?	A platform with hosting & backend services for web apps.
Why use it?	Easy to deploy your HTML, CSS, & JS sites.
Step-by-Step Guide	Sign up at netlify.com Go to the ‘Sites’ tab and click ‘Add new site’. Select ‘Deploy manually’ Drag & drop your folder Your site is live, & the domain can be customized!

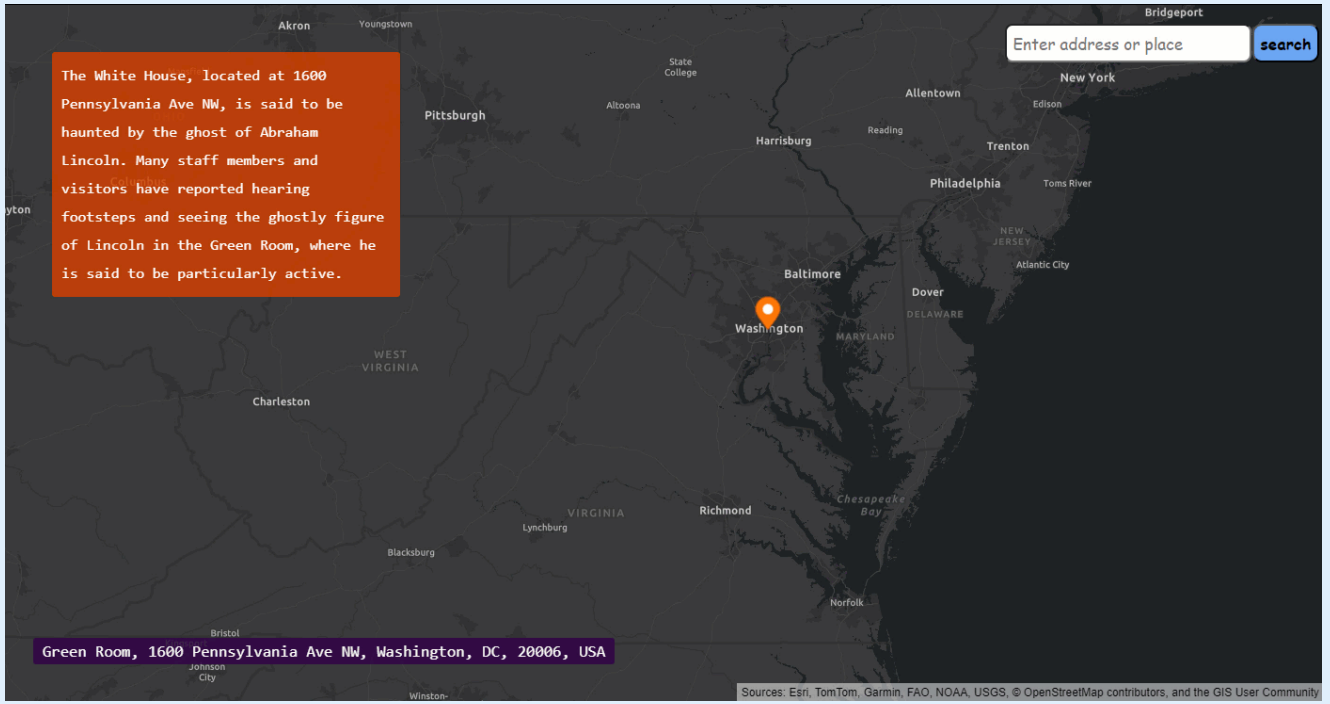
Fun Facts Map built with AI

Using the OpenAI API and ArcGIS location services in a MapLibre GL JS map

- **Repository:** github.com/cyatteau/open-ai-scary-facts-map
- **Hosted app:** scary-facts-map.netlify.app/

📽 OpenAI + JS Video Resources 📽

- Build ChatGPT in JS
- Learn to use OpenAPI (React Node.js)



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Create and Share your Own Maps!

Ideas, Code to Play with, and more

Documentation & Practice

- Leaflet examples and ArcGIS tutorials
- MapLibre GL JS examples and ArcGIS tutorials
- OpenLayers examples and ArcGIS tutorials

Project Ideas

- Create custom styles with VTSE – See my blogs (article 1, article 2)
- Add your own feature layer to a map
- Create a local restaurants map guide
- Create a historical weather events map
- Create a tourist attraction audio tour

YouTube Videos

- **MapTiler Channel**
  - MapLibre tutorials
  - Leaflet tutorials
- **GeoDev Channel**
  - Leaflet Crash Course
- **My Channel (@c_yatteau)**
  - Esri Leaflet Playlist
  - MapLibre GL JS Basics Playlist
  - ArcGIS Developer Playlist

Other

- Raul's geospatial resources
- Tons of free & open data

Extend your Learning & Skills

Go above and beyond

📚 Framework Libraries

- React Leaflet
- MapLibre React Native
- OpenLayers-Vue
- Leaflet Angular

🔗 Geospatial Data Processing

- Turf.js
- GDAL

📊 Data Visualization

- D3.js
- Chart.js

👫 Community & Forums

- GitHub
  - Leaflet, MapLibre GL JS, OpenLayers
- Stack Overflow
  - Leaflet, MapLibre GL JS, OpenLayers