🏠 Geo Footprint Regularization Dashboard

Geo Footprint Regularization

A GeoAI-Powered Tool for Building Footprint Analysis

Overview: This interactive dashboard leverages GeoAI to regularize building footprints and process satellite imagery. Features include adaptive and hybrid regularization, image segmentation, and a chatbot for geospatial queries. Optimized for Google Colab with a focus on computational geometry and visualization.

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Year: 2025
Technologies: **Streamlit**, **GeoPandas**, **Gradio**, **Three.js**

Introduction to GeoAI and Building Footprint Regularization

Foundations and Motivation

GeoAI Defined
GeoAI integrates geospatial data analysis with artificial intelligence to solve spatial problems using machine learning and deep learning.

Importance of Footprint Regularization
Regularizing building footprints improves geometric consistency, essential for urban analytics, simulation, and 3D reconstruction.

Motivation for Automation
Manual correction is time-consuming; AI-driven regularization accelerates processing and enhances accuracy.

Project Objectives and Scope

Purpose, Goals, and Boundaries

Purpose of the Project
To implement and evaluate GeoAI-based regularization techniques for improving building footprint accuracy.

Key Objectives
Analyze orientation detection, orthogonalization, and simplification methods; develop a reproducible GeoAI pipeline.

Scope and Constraints
Focus on 2D footprint correction using open-source data and Python libraries; excludes 3D modeling and real-time applications.

Climate Change Impact Analysis

Analyze flood risk for buildings using geospatial reasoning and regularization. Upload a raster image (e.g., NAIP or DEM) and a GeoJSON file with building footprints, or use default sample data.

Understanding the Analysis

Geospatial Reasoning

Geospatial reasoning uses generative AI to analyze spatial data for climate insights. It identifies patterns like flood risk by combining satellite imagery, elevation data, and vector features. For example, it estimates building vulnerability to floods based on proximity to water or low elevation.

- **Applications:**
- Flood risk assessment
- Urban heat island detection
- Deforestation monitoring

Building Regularization

Regularization simplifies building footprints into consistent shapes (e.g., rectangles or circles) using geometric constraints. In climate change analysis, it standardizes building shapes for flood or heat exposure models, aiding urban resilience planning.

- **Key Parameters:**
- Simplify Tolerance: Smooths edges.
- Diagonal Threshold: Enforces right angles.
- Circle Detection: Identifies circular structures.

Climate Change Relevance

Combining geospatial reasoning and regularization enables precise climate risk assessments. Regularized footprints simplify urban planning models, while reasoning identifies at-risk areas (e.g., flood zones). This demo focuses on flood risk, showing how buildings in low-lying areas can be analyzed for vulnerability.

Data Sources and Preprocessing

Foundations for Geometric Regularization

- **Primary Data Sources:** Used OpenStreetMap (OSM) and curated sample datasets for diverse urban structure input.
- **Environment Setup:** Python ecosystem with GeoPandas, Shapely, Matplotlib for spatial data handling and visualization.
- **Preprocessing Tasks:** Included CRS standardization, geometry validity checks, and format harmonization.

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3	None	Lawngtlai	264	Mizoram	15	2011_c	POLYGON ((92.934562 22.554053, 92.931504 22.394
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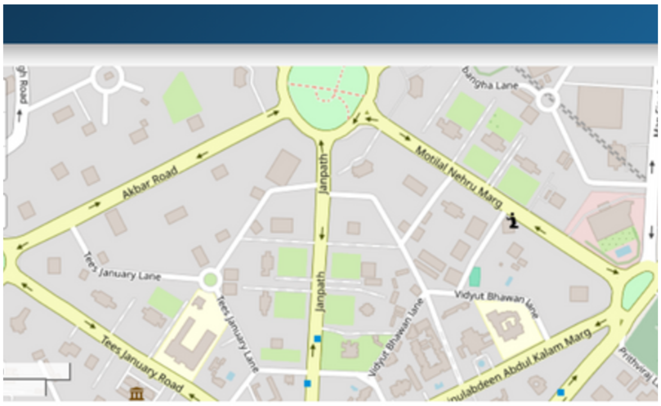
Orthogonalization Principles

Enforcing Angular Constraints in Footprint Geometry

- **Angle Normalization:** Aligns building edges to 90° increments based on detected orientation for cleaner geometry.
- **Edge Alignment:** Refines polygon segments to ensure perpendicular and parallel edges using snapping algorithms.
- **Topology Preservation:** Applies constraints to prevent self-intersections or geometry distortions during transformation.



Simplification Strategies

Optimizing Building Geometry with Fewer Vertices

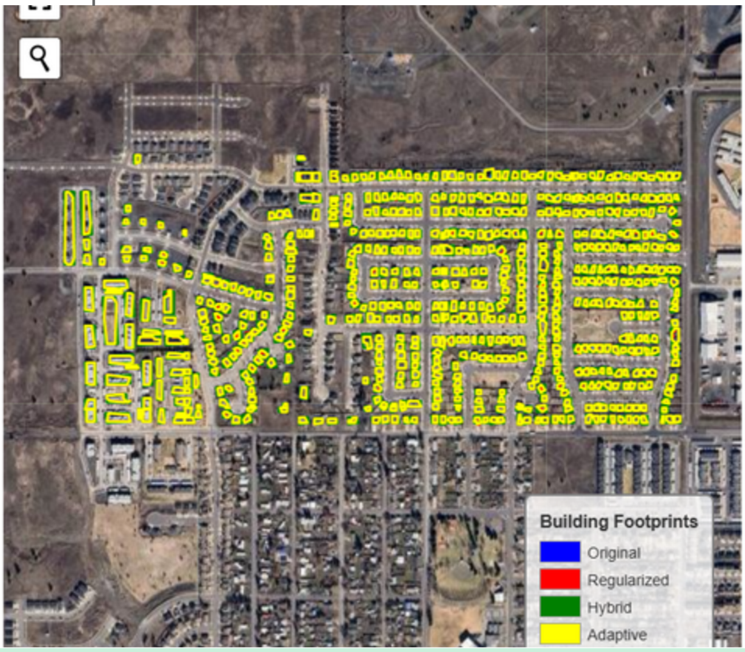
- **Douglas-Peucker Algorithm:** Reduces the number of vertices in a polygon while maintaining its overall shape.
- **Collinear Vertex Elimination:** Removes vertices that lie on straight lines to streamline geometry.
- **Feature-Preserving Simplification:** Applies adaptive thresholds to retain architectural detail where needed.

Photo by Vitaliy Paykov on Unsplash

Implementation and Pipeline Workflow

From Input Data to Regularized Footprints

Modular Function Design
Developed orientation, orthogonalization, and simplification as standalone reusable components.



Results and Performance Metrics

Evaluating Algorithm Effectiveness

- **Visual Assessment:** Regularized footprints show sharper corners, aligned edges, and reduced vertex noise.
- **Processing Speed:** Achieves 250 buildings per minute with current implementation on standard hardware.
- **Success and Error Rates:** 92% of footprints regularized correctly; 8% require manual or adaptive correction.

GEO AI PROCESSING

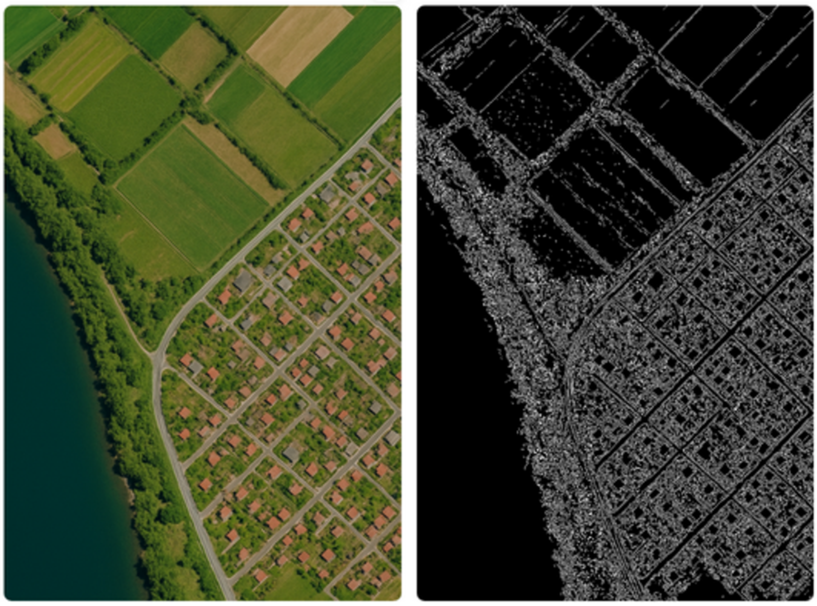


IMAGE MASKING