Synthetic Homes: A Generative AI Framework for Urban Energy Data

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Motivation

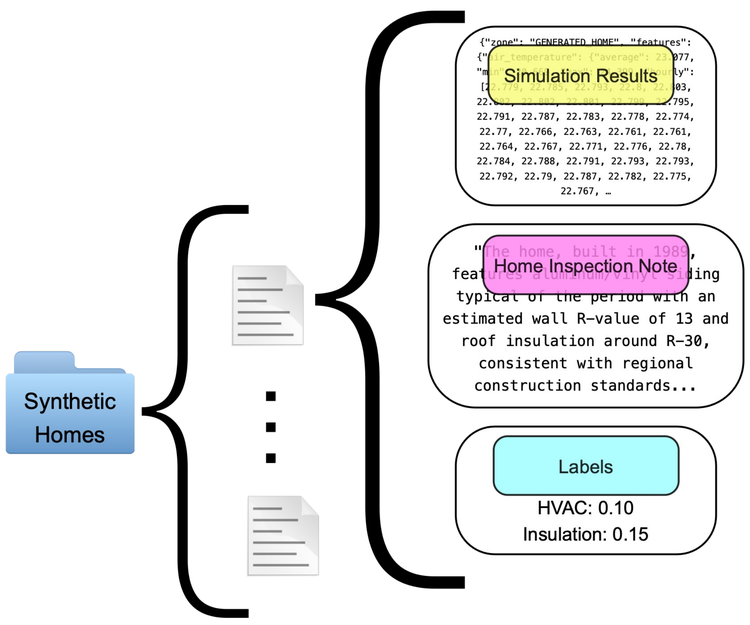
Electricity consumption in the United States has risen sharply in recent decades, intensifying pressure on infrastructure, costs, and emissions. Accurate energy models are critical for planning, but these models often require detailed building data (materials, floor plans, microclimate conditions) that are expensive, scarce, or restricted by privacy concerns. These barriers hinder scalability and limit the effectiveness of existing modeling approaches.

To address this, researchers have explored synthetic data generation and digital twins, yet many approaches rely on costly simulation tools or extensive sensor networks. Recent advances in generative AI provide a new path: producing large volumes of low-cost, multimodal data (text, images, tabular) tailored to specific urban contexts.

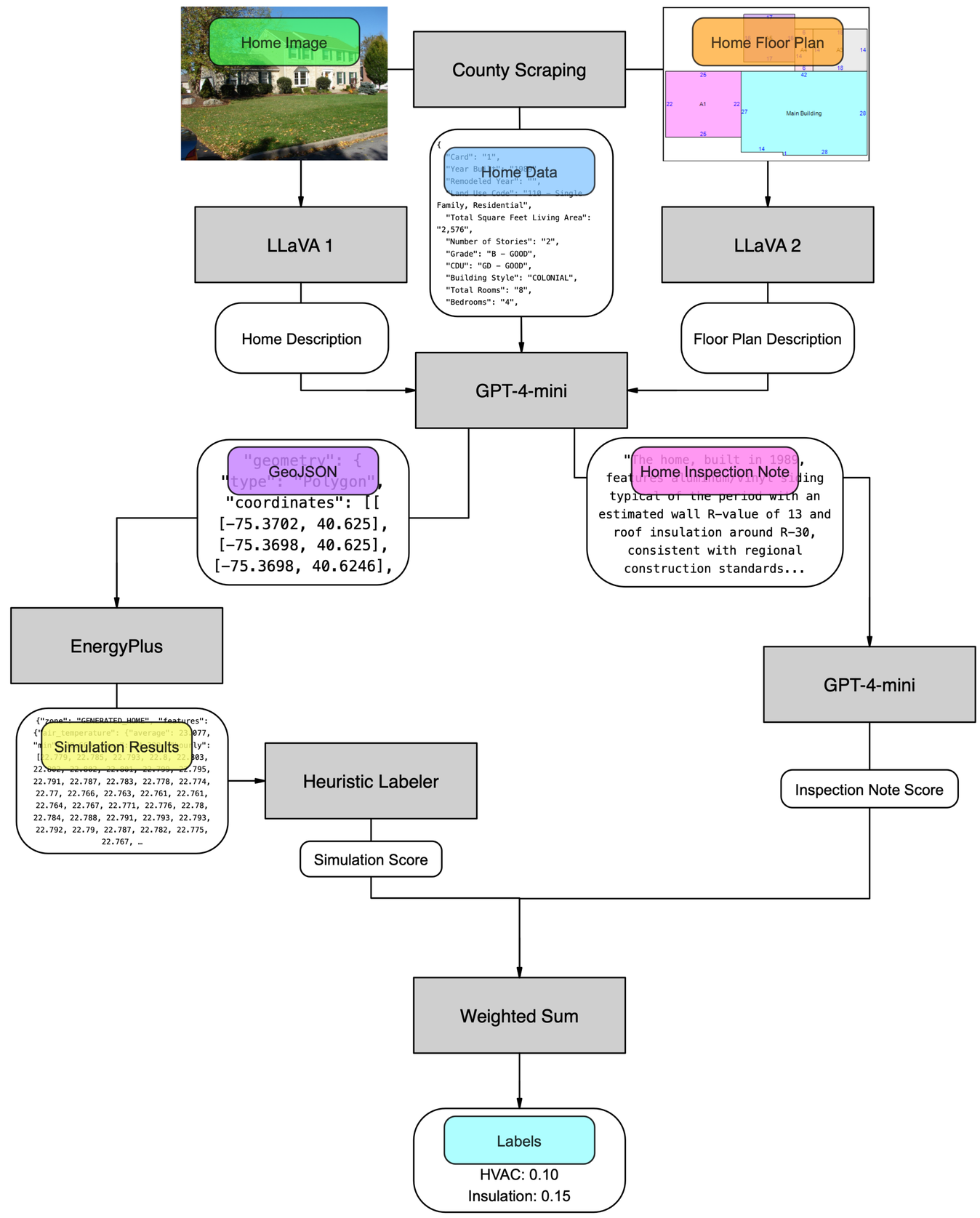
We present a modular generative AI framework for producing synthetic urban building data that integrates pretrained language and vision models with energy simulation tools. Our pipeline enables scalable, low-cost data generation suitable for urban energy modeling, policy evaluation, and decision-making.

Methodology

Our pipeline on the right comprises five modular components that transform public data and generative AI outputs into simulation-ready datasets. The pipeline produces a dataset of synthetic homes, each containing:



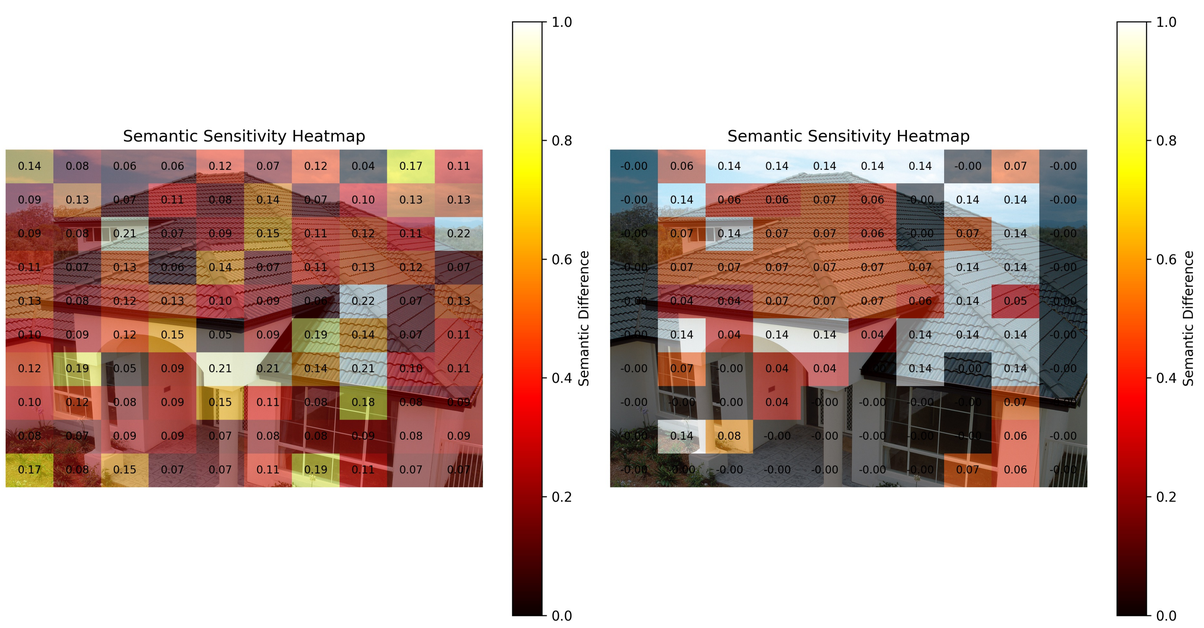
Pipeline



Validation

Vision Model (Occlusion)

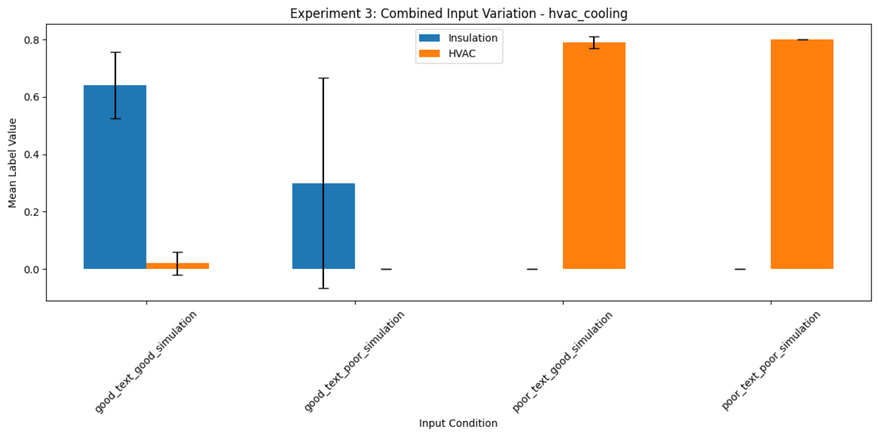
Measured the focus of LLaVA and GPT while analyzing roofs.



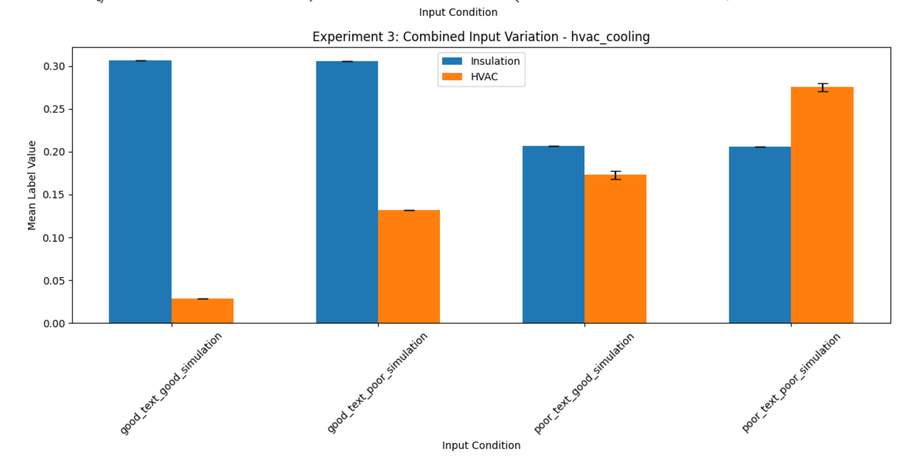
Labeler (Ablation)

Measured bias and optimized for equally weighted inputs.

Before



After



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References

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