Satellite Imagery Based Property Valuation

1. Overview (Approach & Modelling Strategy)

The goal of this project is to predict property prices using both tabular property data and satellite images. While tabular features such as location and other numerical attributes provide useful information, they do not capture the surrounding environment of a property. Satellite imagery helps in incorporating visual context like nearby buildings, roads, and green areas, which can influence property value.

In this project, satellite images are collected using the latitude and longitude of each property and are linked to the corresponding tabular data using a unique property ID. This enables a multimodal learning setup where each data sample contains both structured features and an associated image.

The modelling approach follows two stages. First, a tabular only model is trained to serve as a baseline for property price prediction. Next, a multimodal model is built in which a Convolutional Neural Network (CNN) extracts features from satellite images, and these features are combined with tabular data representations to predict property prices.

The performance of the tabular only model is then compared with the multimodal model to analyse whether incorporating satellite imagery improves prediction accuracy.

2. Exploratory Data Analysis (EDA)

Exploratory Data Analysis was performed to understand the distribution of property prices and to visually inspect the satellite images associated with each property.

Price Distribution

The distribution of property prices in the training dataset was analysed to understand its overall range and spread. The prices exhibit a non uniform distribution with noticeable variation across samples, indicating the presence of both lower and highervalued properties. This variation motivates the use of robust regression models capable of handling skewed price distributions.

Visualizing the price distribution helps in understanding the scale of the target variable and provides context for evaluating model predictions.

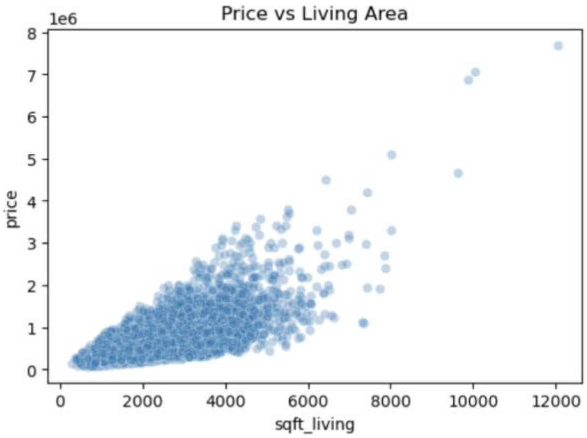
Satellite Image Exploration

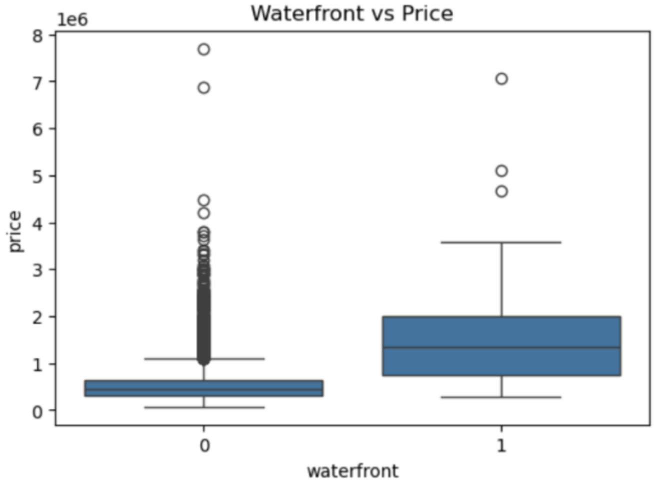
Satellite images corresponding to each property were collected using the **ESRI World Imagery** service through the ArcGIS REST API. Images were fetched based on the latitude and longitude of each property at a fixed zoom level, ensuring consistent spatial resolution across samples.

A subset of satellite images was visually inspected to understand the diversity of surrounding environments. The images reveal variations such as:

- Dense urban regions with closely packed buildings
- Areas with visible road networks
- Regions with higher vegetation or open spaces

This visual diversity supports the hypothesis that satellite imagery contains meaningful contextual information that may influence property prices and complements the structured tabular data.




Waterfront vs Price
1e6
8
7
6
5
4
3
2
1
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price
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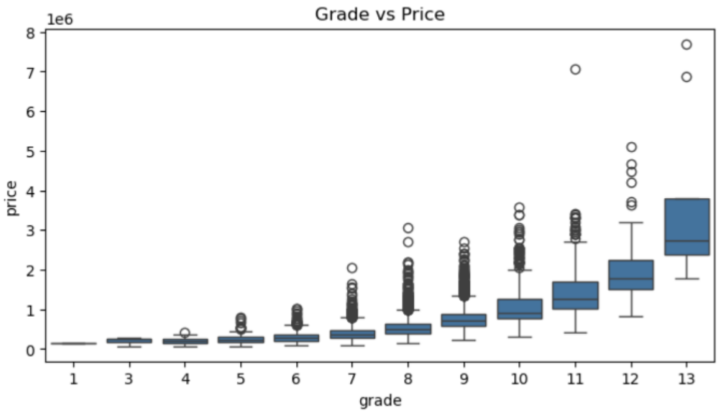
waterfront


Grade vs Price
1e6
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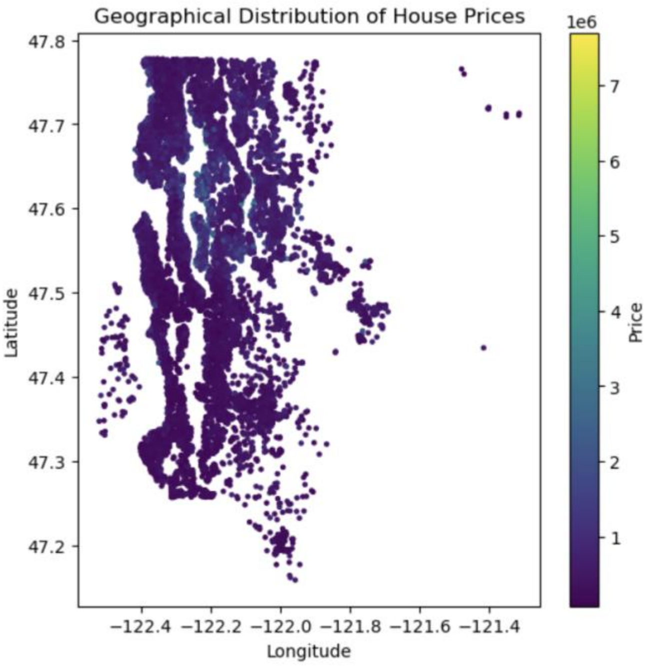
grade


Geographical Distribution of House Prices
47.8
47.7
47.6
47.5
47.4
47.3
47.2
Latitude
−122.4
−122.2
−122.0
−121.8
−121.6
−121.4
Longitude
1e6
7
6
5
4
3
2
1
Price

3. Financial and Visual Insights

Satellite imagery provides visual cues about the surrounding environment of a property, which can have a direct or indirect impact on its market value. By visually inspecting the satellite images, several environmental patterns can be qualitatively associated with property prices.

Properties located in areas with dense urban infrastructure, such as closely packed buildings and well connected road networks, are often associated with higher economic activity and better accessibility. These factors typically contribute to higher property values due to convenience and proximity to amenities.

In contrast, properties surrounded by open land or sparse development may indicate underdeveloped regions, which can be associated with lower property prices. However, in some cases, the presence of green spaces or vegetation can positively influence property value by improving liveability and environmental quality.

Satellite images also highlight differences in land usage patterns, such as residential clusters versus industrial or undeveloped zones. These visual distinctions provide contextual information that is not explicitly available in tabular features but can still influence pricing trends.

By incorporating satellite imagery into the modelling pipeline, the multimodal approach allows the model to implicitly learn such visual patterns and their relationship with property prices, complementing the structured information provided by tabular data.

Architecture Diagram

The overall model architecture follows a multimodal design, combining satellite image features with tabular property features for price prediction. The architecture consists of two parallel branches followed by a fusion stage.

Image Branch

Satellite images corresponding to each property are passed through a Convolutional Neural Network (CNN). The CNN acts as a feature extractor, learning high level spatial and visual representations from the satellite imagery. The output of the CNN is a fixed length image feature vector.

Tabular Branch

The tabular property features are processed using a fully connected neural network (MLP). This branch learns relationships between structured numerical features and transforms them into a latent tabular feature representation.

Feature Fusion and Prediction

The feature vectors obtained from the image branch and the tabular branch are concatenated to form a combined multimodal representation. This fused feature vector is then passed through additional fully connected layers, which learn interactions between visual and tabular features. The final output layer produces a single continuous value representing the predicted property price.

Architecture Flow

Satellite Image —> CNN —> Image Features ┐

├> Concatenation –> FC Layers –> Price

Tabular Features –> MLP —> Tabular Features ┘

This architecture enables the model to jointly leverage visual context from satellite images and structured information from tabular data for property valuation.

Results

The performance of the property valuation system was evaluated by comparing two models: a tabular only model and a multimodal model that incorporates both tabular data and satellite imagery.

Tabular only Model

The tabular only model was trained using structured property features without any visual input. This model serves as a baseline to assess how well property prices can be predicted using only traditional tabular data. The results from this model establish a reference point for evaluating the benefit of incorporating satellite imagery.

Multimodal Model (Tabular + Satellite Imagery)

The multimodal model uses both tabular features and satellite images as inputs. Satellite images are processed through a CNN to extract visual features, which are then combined with tabular feature representations. This fused representation is used to predict property prices.

Compared to the tabular only model, the multimodal model demonstrates improved prediction performance. The inclusion of satellite imagery provides additional contextual information about the surrounding environment, which helps the model make more accurate price estimates.

Comparison Summary

The comparison between the two models shows that incorporating satellite imagery leads to better performance than relying solely on tabular data. This indicates that visual context captured from satellite images adds meaningful information for property valuation tasks.

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