RealValuator: Real Estate Price Predictor

A Project Work-I Report

Submitted in partial fulfillment of requirement of the

Degree of

BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE & ENGINEERING

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Report Approval

The project work **RealValuator: Real Estate Price Predictor** is hereby approved as a creditable study of an engineering/computer application subject carried out and presented in a manner satisfactory to warrant its acceptance as prerequisite for the Degree for which it has been submitted.

It is to be understood that by this approval the undersigned do not endorse or approved any statement made, opinion expressed, or conclusion drawn there in; but approve the "Project Report" only for the purpose for which it has been submitted.

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Declaration

We hereby declare that the project entitled **RealValuator: Real Estate Price Predictor** submitted in partial fulfilment for the award of the degree of Bachelor of Technology/Master of in Computer Science completed under the supervision of **Prof. Shivani Patnaha (Assistant Professor)** & **Prof. Dhiraj Kumar (Assistant Professor),** Faculty of Engineering, Medi-Caps University Indore is an authentic work.

Further, we declare that the content of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for the award of any degree or diploma.

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We, **Prof Shivani Patnaha** and **Prof. Dhiraj Kumar** certify that the project entitled **RealValuator: Real Estate Price Predictor** submitted in partial fulfillment for the award of the degree of Bachelor Technology by **Harshita Chouhan, Harshita Mantri, Harshita Parmar** is the record carried out by them under our guidance and that the work has not formed the basis of award of any other degree elsewhere.

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Abstract

The real estate sector is a complex, dynamic, and highly data-dependent industry where property valuation plays a critical role in decision-making for buyers, sellers, investors, and financial institutions. Traditional valuation methods such as Comparative Market Analysis (CMA), manual appraisal, and broker-driven assessments often suffer from subjectivity, inconsistency, and limited scalability. These limitations create uncertainty in pricing, reduce market transparency, and make it difficult for stakeholders to make informed decisions. To address these challenges, this project presents **RealValuator – Real Estate Price Predictor**, an intelligent, machine learning–based system designed to generate accurate, fair, and data-driven property price predictions.

RealValuator integrates modern data analytics and supervised **machine learning algorithms, including Linear Regression, Decision Trees, Random Forest, Gradient Boosting, and XGBoost,** to estimate real estate prices based on multiple property attributes such as location, area, number of rooms, amenities, and surrounding infrastructure. The system follows a comprehensive methodology involving data acquisition, preprocessing, exploratory data analysis (EDA), feature engineering, model training, evaluation, and deployment. In the preprocessing stage, missing values, duplicates, and outliers are handled effectively, while categorical variables are encoded and numerical features are normalized. EDA provides insights into correlations, spatial variations, market trends, and influential factors affecting price fluctuations.

Multiple machine learning models are trained and evaluated using metrics such as R^2 Score, Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE), enabling the selection of the optimal model for deployment. The system is developed using **a Python-based backend (Flask/Django)** and a **React/Streamlit frontend**, ensuring a scalable and interactive user experience. Users can enter property details through a simple web interface and receive instant price predictions, along with visualization dashboards that highlight feature importance, area-wise comparisons, and price distribution trends.

RealValuator aims to bridge the gap between traditional appraisal techniques and modern predictive analytics by offering enhanced reliability, transparency, and interpretability. The system empowers stakeholders to make data-driven decisions, reduces dependence on subjective assessments, and contributes to a more efficient and trustworthy real estate market. With further enhancements such as time-series forecasting, geospatial analysis, and integration of external market indicators, RealValuator has the potential to evolve into a comprehensive real estate intelligence platform supporting large-scale real estate analytics and smart city application.

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ABBREVIATIONS

Abbreviation	Full Form
AI	Artificial Intelligence
API	Application Programming Interface
CMA	Comparative Market Analysis
CPU	Central Processing Unit
DFD	Data Flow Diagram
ER Diagram	Entity Relationship Diagram
SQL	Structured Query Language
GUI	Graphical User Interface
HTML	HyperText Markup Language
HTTPS	HyperText Transfer Protocol Secure
JSON	JavaScript Object Notation
JWT	JSON Web Token
MAE	Mean Absolute Error
ML	Machine Learning
MSE	Mean Squared Error
MVC	Model–View–Controller
ORM	Object Relational Mapping

Chapter-1: INTRODUCTION

1.1 Introduction

The real estate industry is one of the most influential and fast-growing sectors of the global economy, playing a crucial role in urban development, investment planning, and individual financial decisions. Property valuation, a central component of this sector, involves estimating the market value of residential or commercial properties based on various attributes such as location, area, architecture, infrastructure, and market demand. Traditionally, this valuation process has been conducted through manual appraisal, brokers' opinions, or Comparative Market Analysis (CMA). While these methods provide useful insights, they are often subjective, inconsistent, time-consuming, and limited in their ability to process large and complex datasets. As a result, buyers frequently face uncertainty regarding fair prices, sellers encounter challenges in setting competitive prices, and investors struggle to analyze market trends effectively.

In recent years, rapid advancements in Artificial Intelligence (AI), Machine Learning (ML), and data analytics have revolutionized the way predictive systems are developed across various industries. Real estate, being heavily data-driven, offers a significant opportunity to apply modern analytical techniques for accurate, scalable, and unbiased price prediction. Machine learning algorithms such as **Linear Regression, Random Forest, Gradient Boosting, and XGBoost** have demonstrated exceptional performance in modeling multi-dimensional relationships and identifying nonlinear patterns within complex datasets. By leveraging these techniques, property valuation can be made more reliable, faster, and transparent.

RealValuator – Real Estate Price Predictor is developed with the aim of utilizing supervised machine learning algorithms to provide fair and data-backed property price estimations. The system focuses on creating an end-to-end pipeline that includes data acquisition, preprocessing, exploratory data analysis (EDA), model training, evaluation, visualization, and deployment. Through EDA, the project identifies key patterns, correlations, price fluctuations, and influential features that significantly impact property values. By training and evaluating multiple models, the system ensures the selection of the most accurate and robust model for real-time predictions.

The system is designed for practical usability, offering an interactive and user-friendly web interface where users can input property details such as location, size, number of rooms, and amenities. Upon input, RealValuator processes the data through its trained ML model and produces a real-time estimated price.

Additionally, the system provides visualization dashboards to enhance understanding by showcasing area-wise price distributions, feature impacts, and market insights. These visualizations help stakeholders such as buyers, sellers, investors, and real estate agents make informed decisions with greater confidence.

The overarching goal of RealValuator is not merely to predict property prices but to contribute to a **more transparent, efficient, and data-driven real estate ecosystem**. By minimizing human subjectivity and offering analytical insights, the system bridges the gap between traditional valuation methods and modern computational intelligence. Future extensions of the system include the incorporation of time-series forecasting, integration of geospatial analysis, automated dataset retrieval, and the addition of external factors such as economic indicators, interest rates, and government policies. These enhancements will further strengthen the system's accuracy, scalability, and applicability in real-world scenarios.

In essence, RealValuator represents a powerful fusion of machine learning, data analytics, and web-based technologies—aimed at redefining traditional real estate valuation and empowering users with actionable, reliable, and transparent insights.

1.2 Objective

1. Accurate Property Price Prediction

- Train and evaluate multiple supervised machine learning algorithms such as Linear Regression, Decision Trees, Random Forest, Gradient Boosting, and XGBoost.
- Achieve high accuracy using performance metrics like **R^2 Score, MAE, MSE, and RMSE**.
- Select the best-performing model for real-time price prediction.

2. Data Preprocessing and Feature Engineering

- Clean and preprocess real estate datasets by handling missing values, removing duplicates, and managing outliers.
- Encode categorical features (e.g., location) and normalize numerical attributes to improve model performance.

- Identify and engineer important features that significantly impact pricing.

3. Support for Buyers and Sellers

- Help **buyers** determine whether a property is overpriced or underpriced.
- Assist **sellers** in setting competitive and realistic property prices based on objective, data-driven insights.

4. Enhanced Market Transparency

- Reduce dependency on brokers and manual appraisals by offering unbiased, algorithmic predictions.
- Promote fairness and clarity in property transactions by presenting evidence-based price estimations.

5. Visualization and Interpretability

- Provide comprehensive dashboards to visualize:
  - Price trends and distributions
  - Area-wise comparisons
  - Correlation between property features
  - Feature importance using techniques like SHAP or permutation importance
- Improve interpretability and understanding of the factors influencing property prices.

1.3 Overview of Project

- RealValuator is a machine learning–based system designed to predict real estate property prices accurately.
- It analyzes key factors such as location, area, number of rooms, amenities, and nearby infrastructure.
- The system replaces traditional valuation methods that are often subjective, slow, and inconsistent.
- It provides fast and reliable predictions through a user-friendly web interface.

- Users can input property details and receive real-time price estimates.
- Visualization dashboards display market insights such as price trends, area-wise comparisons, and feature importance.
- The project supports buyers, sellers, agents, and investors in making data-driven decisions.
- It enhances transparency and reduces dependency on manual property appraisals.
- RealValuator demonstrates the use of modern machine learning to solve real-world challenges in property valuation.

1.4 Significance

- **Provides Accurate Price Estimation:**
  RealValuator improves the precision of property valuation by using machine learning algorithms that analyze multiple features, reducing human error and guesswork.
- **Enhances Market Transparency:**
  It offers unbiased, data-driven price predictions, helping buyers and sellers understand the fair value of a property, thereby promoting trust in real estate transactions.
- **Supports Informed Decision-Making:**
  The system assists stakeholders—buyers, sellers, agents, and investors—by offering analytics, price trends, and feature importance insights for better decision-making.
- **Saves Time and Effort:**
  Automated predictions eliminate the need for manual appraisals, reducing dependency on brokers and speeding up the valuation process.
- **Reduces Subjectivity and Fraud:**
  By replacing opinion-based valuations with algorithmic predictions, the project minimizes overpricing, underpricing, and fraudulent pricing practices.
- **Useful for Financial Institutions:**
  Banks and lenders can use the system for risk assessment and loan evaluation by verifying whether a property's price aligns with market trends.
- **Scalable and Future-Ready:**
  The platform can be expanded with time-series forecasting, geospatial mapping, and real-time market data, making it suitable for long-term adoption.

1.5 Literature Review:

The prediction of real estate prices has been widely studied due to the complex nature of property markets, where prices are influenced by multiple interdependent factors such as location, property size, amenities, and market conditions. Early research in this domain primarily relied on traditional statistical techniques such as hedonic pricing models, which expressed property value as a function of its structural and locational attributes. Although these models provided interpretability, they assumed linear relationships and were unable to capture nonlinear trends present in real-world datasets. With advancements in data science, researchers began adopting machine learning approaches including Linear Regression, Decision Trees, Random Forest, Gradient Boosting, and Support Vector Regression. These models offered improved accuracy, especially ensemble techniques like Random Forest and XGBoost, which handle high-dimensional data and complex interactions more effectively. Recent studies have also explored deep learning approaches such as Artificial Neural Networks, CNNs, and hybrid models to incorporate image-based and textual data, achieving higher accuracy but requiring large datasets and computational resources. Spatial and geostatistical models further enhanced predictions by integrating geographic and neighbourhood-level information. Despite these advancements, several gaps persist, including limited interpretability, poor data quality handling, and lack of real-world deployment. Addressing these gaps, the RealValuator system combines advanced machine learning techniques with visualization dashboards and a user-friendly interface to provide accurate, transparent, and practical property valuation.

1.6 Research Design

The research design for the **RealValuator** project follows a systematic, data-driven approach aimed at developing an accurate and reliable real estate price prediction system. The study adopts an **experimental research design**, where different machine learning models are trained, tested, and compared to identify the most effective prediction technique. The research process is divided into multiple stages, each contributing to the development of a robust and scalable system.

The design begins with **problem identification and requirement analysis**, where gaps in traditional valuation methods are examined. This is followed by **data collection**, where real estate datasets containing information such as location, area, rooms, and amenities are gathered from open-source repositories or market databases. The collected data undergoes **preprocessing**, including handling missing values, removing duplicates, encoding categorical variables, and normalizing numerical features.

Next, **Exploratory Data Analysis (EDA)** is conducted to identify patterns, correlations, outliers, and influential factors that affect property prices. Insights from EDA guide feature selection and engineering. The system then transitions to the **model development phase**, where multiple algorithms—such as Linear Regression, Decision Tree, Random Forest, Gradient Boosting, and XGBoost—are trained on the processed data. Each model is evaluated using performance metrics like R^2 Score, MAE, MSE, and RMSE to determine accuracy and reliability.

The best-performing model is selected and integrated into the application using a Python-based backend. A **prototype system** is developed with an interactive user interface that allows users to input property details and receive real-time predictions. Additionally, visualizations such as price distributions, feature importance charts, and area-wise comparisons are incorporated to enhance interpretability.

Finally, the system undergoes **testing, validation, and refinement** to ensure functionality, accuracy, usability, and performance. The research concludes with the deployment of the model on a web platform, making it accessible to real-world users. Overall, this structured research design ensures that RealValuator is data-driven, transparent, and practical for stakeholders in the real estate domain.

1.6.1 Problem Identification

The real estate market is highly dynamic, with property prices influenced by numerous factors such as location, area, amenities, infrastructure, and market conditions. Traditional valuation methods—like broker opinions, manual appraisal, or comparative market analysis—are often subjective, inconsistent, and lack transparency. These methods depend heavily on human judgment, leading to contradictory valuations for the same property. Additionally, buyers and sellers face difficulty determining the fair market value, while investors struggle to analyze trends due to limited data-driven insights. Existing digital tools either provide generic estimates or fail to incorporate multiple influential features effectively. Moreover, many research models focus purely on algorithmic accuracy and lack real-world usability, interpretability, and deployment. As a result, there is a clear need for an automated, accurate, and transparent system that leverages machine learning to predict property prices reliably and supports users in making informed real estate decisions.

1.6.2 Objectives of the Study

The primary objective of this study is to develop an intelligent, machine learning–based system capable of accurately predicting real estate property prices using multiple influential features. The study aims to replace subjective and inconsistent traditional valuation methods with a transparent, data-driven approach. The specific objectives are:

- **To identify the key factors influencing property prices**, such as location, area, amenities, and infrastructure.
- **To preprocess and analyze real estate datasets** for extracting meaningful patterns and relationships.
- **To build and compare machine learning models** (Linear Regression, Decision Tree, Random Forest, XGBoost) for property price prediction.
- **To evaluate the performance of each model** using metrics such as R^2 Score, MAE, MSE, and RMSE.
- **To select and implement the best-performing model** for real-time price prediction.
- **To design a user-friendly interface** that enables users to input property details and instantly receive accurate price estimates.
- **To provide visualization dashboards** that help users understand market trends, feature importance, and pricing variations.
- **To enhance transparency and decision-making** for buyers, sellers, agents, and investors through accurate, unbiased valuations.

1.6.3 Research Methodology

The research methodology for this study follows a systematic, data-driven, and experimental approach aimed at developing an accurate and reliable real estate price prediction system. The methodology is divided into several well-defined phases:

1. Problem Understanding and Requirement Analysis

The study begins with identifying the limitations of traditional property valuation methods and understanding the need for a machine learning–based prediction system. Requirements for data, tools, models, and system design are clearly defined.

2. Data Collection

Real estate datasets are collected from publicly available sources, online repositories, or real estate platforms. The dataset includes features such as location, area, number of rooms, amenities, and price.

3. Data Preprocessing

Raw data undergoes cleaning and transformation to ensure quality and consistency.
This includes:

- Handling missing values
- Removing duplicates
- Treating outliers
- Encoding categorical variables
- Normalizing numerical features

4. Exploratory Data Analysis (EDA)

EDA is performed to study correlations, patterns, trends, and feature distributions. Visual techniques such as heatmaps, scatter plots, and histograms are used to understand influential attributes and market behavior.

5. Model Development

Multiple supervised machine learning algorithms are implemented to compare their performance, including:

- Linear Regression
- Decision Tree Regressor
- Random Forest Regressor

- Gradient Boosting / XGBoost

Each model is trained using the cleaned dataset and optimized with appropriate hyperparameters.

6. Model Evaluation

The models are evaluated using performance metrics such as:

- R^2 Score
- Mean Absolute Error (MAE)
- Mean Squared Error (MSE)
- Root Mean Squared Error (RMSE)

The best-performing model is selected for deployment based on accuracy and consistency.

7. System Development

A functional system is designed using a Python-based backend (Flask/Django) to serve the trained model. A user-friendly interface is created to allow users to input property details and view predicted prices.

8. Visualization and Interpretation

Dashboards are created to display price trends, area-wise comparisons, and feature importance, enhancing understanding and transparency.

9. Testing and Validation

The system undergoes functional testing, performance testing, and user validation to ensure reliability, accuracy, and usability.

10. Deployment and Documentation

The model is deployed as a web application on cloud platforms such as AWS or Heroku. Comprehensive documentation is prepared to support future maintenance and enhancements.

1.7 Source of Data

The data used in this study is obtained from multiple reliable and publicly accessible sources to ensure accuracy, diversity, and relevance to real estate pricing. The datasets primarily include property details such as location, area, number of rooms, amenities, and market prices. The key sources of data for this project are:

- **Open-source real estate datasets** available on platforms such as Kaggle, GitHub, and government open data portals.
- **Public real estate listing websites**, which provide real-time property information, price trends, and location-based features.
- **Government and municipal records**, offering locality data, infrastructure details, and demographic factors that influence property prices.
- **Manually collected or curated datasets**, compiled through publicly available listings and property records.
- **Supplementary datasets**, such as neighborhood amenities, distance to facilities, and area-level infrastructure data, to enhance model accuracy and context.

These diverse data sources ensure that the machine learning model is trained on comprehensive, real-world, and up-to-date information, resulting in more reliable and practical price predictions.

Chapter-2:

REQUIREMENTS SPECIFICATION

2.1 User Characteristics

The RealValuator system is designed for a diverse group of users with varying technical expertise:

1. General Users (Buyers/Sellers)

- May have limited technical knowledge.
- Require a simple and intuitive interface for entering property details.

- Expect quick and accurate price predictions to help in decision-making.

2. Real Estate Agents / Brokers

- Possess moderate understanding of market trends.
- Need accurate, data-driven insights to support property consultation.
- Use predictive results to compare multiple properties for clients.

3. Investors / Analysts

- Have higher analytical skills.
- Require detailed dashboards, trend analysis, and feature importance insights.
- Depend on accurate predictions for investment planning and risk assessment.

4. System Administrators (Optional)

- Possess technical background.
- Responsible for dataset updates, model retraining, user management, and maintenance.
- Ensure smooth functioning and security of the system.

2.2 Functional Requirements

The following functions describe what the system must perform:

1. User Input and Data Handling

- The system shall allow users to input property details (location, area, rooms, amenities).
- The system shall validate and preprocess the input data before prediction.

2. Price Prediction

- The system shall use a trained machine learning model (Random Forest/XGBoost/Linear Regression) to generate price estimates.
- The system shall display predictions in real time (< 2 seconds).

3. Data Preprocessing

- The system shall handle missing values, categorical encoding, and normalization.
- The system shall transform user input into a model-compatible format.

4. Visualization Features

- The system shall generate visual insights such as:
  - Area-wise price comparison
  - Feature importance
  - Price distribution
  - Correlation heatmaps

5. User Interface

- The system shall provide a clean, easy-to-navigate interface.
- The UI shall include input forms, output results, and dashboard features.

6. Model Training and Evaluation (Backend Functionality)

- The system shall allow the training of different ML models.
- The system shall evaluate models using R^2, MAE, MSE, and RMSE.
- The best-performing model shall be saved for deployment.

7. Database Integration (Optional)

- The system shall store historical predictions and user inputs.
- The system shall allow periodic retraining using stored data

8. Reports and Exports

- The system shall allow users to download the prediction results or reports (PDF/CSV).

9. Admin Features (Optional)

- Admin can update datasets, retrain models, and monitor system usage.

2.3 Dependencies

The performance and functioning of RealValuator depend on the following:

1. Software Dependencies

- **Python** (for ML model development)
- **Flask/Django** (for backend API)
- **React** (for frontend/user interface)
- **Libraries:** Pandas, NumPy, Scikit-learn, XGBoost, Matplotlib, Seaborn
- **Database:** MySQL/PostgreSQL (optional)

2. Hardware/Platform Dependencies

- A computer or server capable of running machine learning models.
- Stable internet connection for web-based access.
- Cloud platform (AWS/Heroku/GCP) for deployment and hosting.

3. Data Dependencies

- Availability of reliable, updated real estate datasets.
- High-quality data for accurate training and evaluation.
- Additional datasets for location, amenities, and market trends (optional).

4. External Dependencies

- Third-party libraries and frameworks used for ML and visualization.
- Browser compatibility for frontend interface.
- Cloud services availability for deployment and scaling.

Chapter 3: SYSTEM DESIGN

The System Design chapter describes the architectural structure, data flow, database schema, module interactions, and interface layout of the Secure API Marketplace. This chapter translates the requirements identified earlier into a technical design blueprint that guides implementation. The focus is on developing a secure, scalable, and modular platform that supports API publishing, key management, sandbox testing, and transparent usage logging.

3.1 System Architecture

The architecture of the RealValuator system follows a **three-tier architecture**, ensuring modularity, scalability, and efficient data processing. The system is divided into three major layers:

1. **Presentation Layer (Frontend)**
2. **Application Layer (Backend / ML Engine)**
3. **Data Layer (Database and Dataset Storage)**

This architecture enables seamless communication between the user interface, machine learning model, and stored data, ensuring smooth real-time property price prediction and visualization.

3.1.1 Presentation Layer (Frontend)

The Presentation Layer is responsible for interacting with the users. It provides all visual components and manages user inputs.

1.Key Features:

- Web-based user interface designed using **React.js** or **Streamlit**.
- Input forms for users to enter property details (location, area, rooms, amenities).
- Visualization dashboards for:
    - Price trends
    - Feature importance
    - Area-wise comparisons

    - Prediction output
- Responsive design to support desktop and mobile devices.
- Communicates with the backend through RESTful API calls.

2.Responsibilities:

- Collect user input.
- Display prediction results returned by the backend.
- Present graphical insights using charts and visual elements.
- Ensure user-friendly navigation and interface usability.

3.1.2 Application Layer (Backend)

The Application Layer handles all logical processing, machine learning tasks, and communication between the frontend and database.

1.Key Components:

- **Flask/Django backend** responsible for handling API requests.
- **Machine learning model** (Random Forest, XGBoost, or Linear Regression) loaded into the backend for prediction.
- **Preprocessing pipeline** to convert user input into model-compatible format.
- **Business logic** to process requests, validate data, and deliver results.

2.Responsibilities:

- Receive user inputs from the frontend.
- Preprocess input data: encoding, scaling, transformation.
- Apply the trained ML model to predict property price.
- Return prediction results in JSON format.
- Manage communication between database and user interface.
- Support additional ML tasks like retraining, evaluation, and logging.

3.1.3 Data Layer (Database)

The Data Layer stores all data used by the system, including datasets for training, user inputs, and prediction history.

1.Key Components:

- **Database Management:** MySQL or PostgreSQL (optional depending on project scope).
- **Dataset Storage:** CSV/Excel files used for training ML models.
- **Historical Prediction Storage (if enabled)**.

2.Responsibilities:

- Store real estate datasets used for model training.
- Maintain user queries, prediction results, and logs.
- Store processed data for future model retraining.
- Support scalability by allowing updates with new property records.
- Ensure data consistency, integrity, and easy retrieval.

3.2 Module Description

The system comprises the following core modules:

1. Authentication Module

Handles secure user registration, login, and session management using express-session and bcrypt password hashing. Only authenticated users can publish APIs or generate keys.

2. API Publishing Module

Allows API Providers to submit API information including name, category, endpoint, request format, response schema, and documentation. Users can edit or delete their entries.

3. API Key Management Module

Generates scoped, expiring, and encrypted keys. Keys are masked for display and stored securely using AES/RSA encryption. Expiry rules prevent misuse.

- **Sandbox Testing Module**

Enables API Consumers to test APIs without using real keys. The sandbox returns simulated mock responses, reducing security risks while allowing experimentation.

- **Usage Logging Module**

Records all API calls, including:

- Timestamp
- Endpoint
- API key used
- Status code

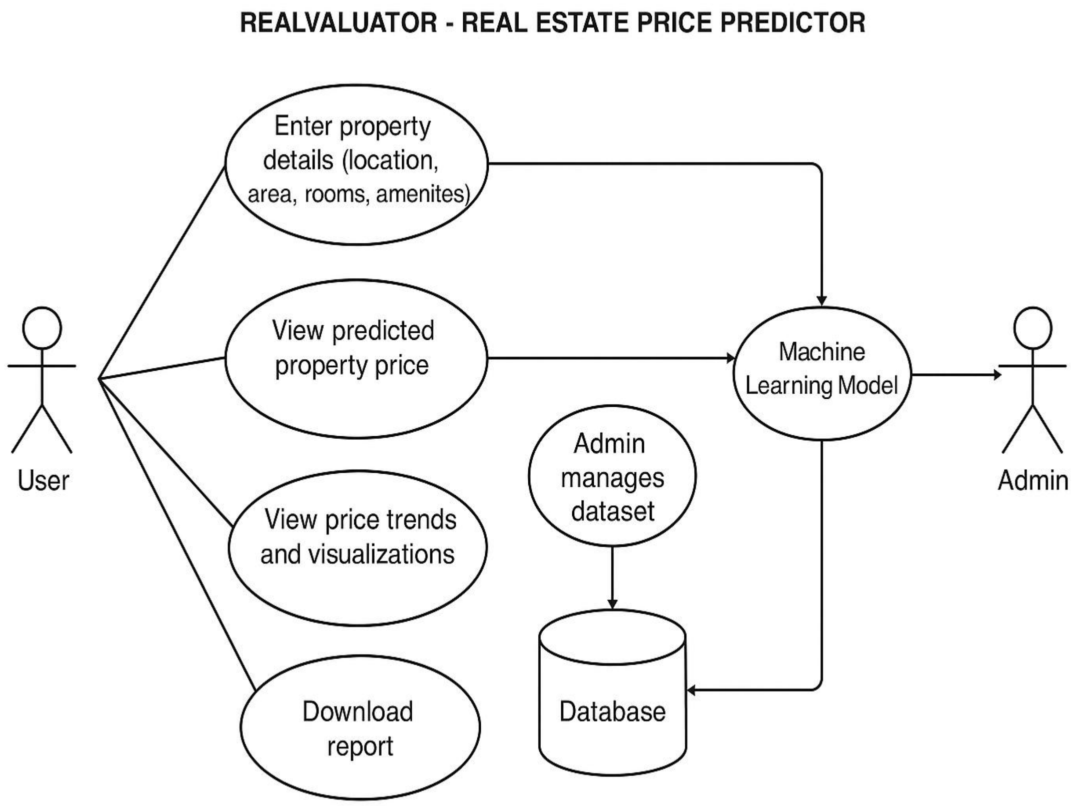
Logs are immutable and view-only to preserve transparency.

3.3 System design

The system design of RealValuator defines how different components interact to deliver property price predictions efficiently. It outlines the functional flow between users, backend services, machine learning modules, and the database. The design focuses on modularity, scalability, and secure interaction among system components. It ensures that users can input property details, the backend can process the request, the ML model can predict property values, and the output is displayed in a user-friendly format.
This section highlights the system behavior through use case diagrams and identifies major actors and their interactions.

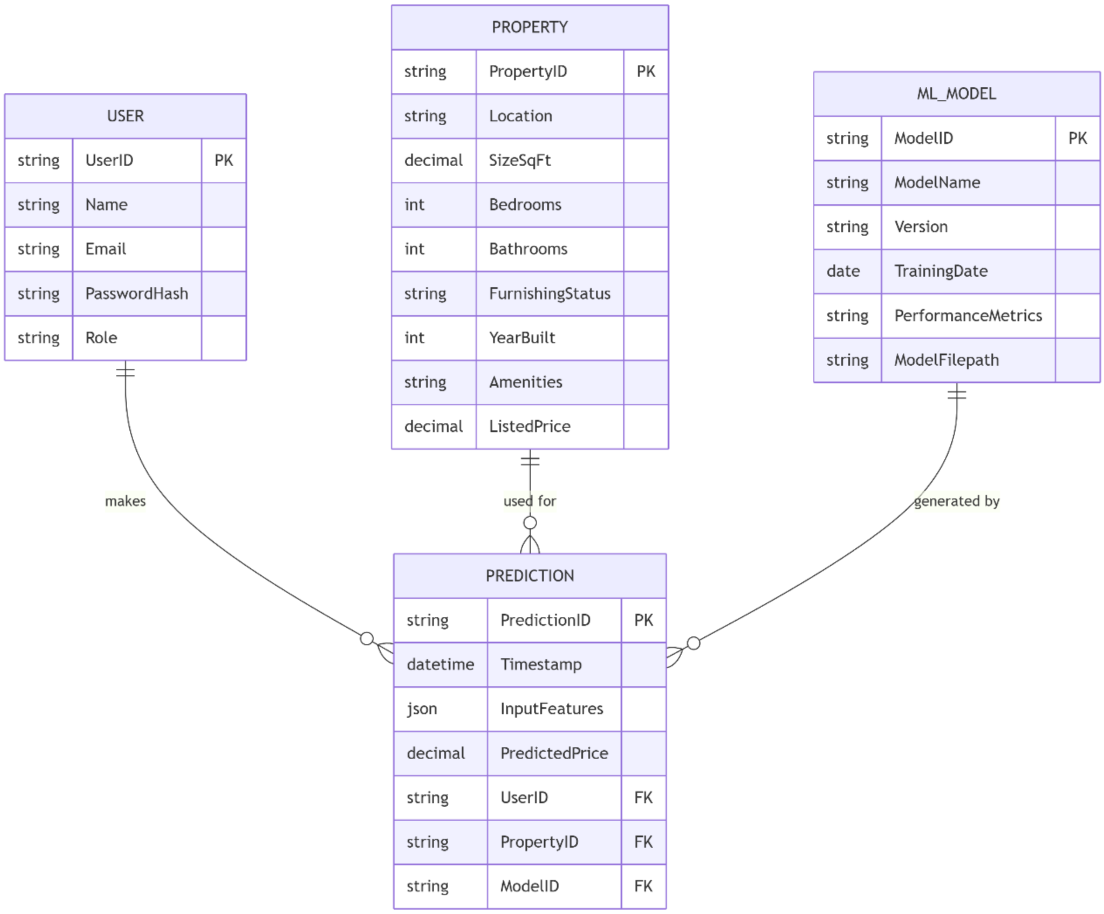
3.3.1 Use Case Diagram

The Use Case Diagram represents the interaction between the main actors and the RealValuator system. The primary actors are the User, who may be a buyer, seller, agent, or investor, and the Admin, who manages system operations. The diagram illustrates how users interact with the system to perform essential tasks such as registering or logging in, entering property details, requesting price predictions, viewing predicted values, and accessing market insights. It also shows optional features like reviewing prediction history for future reference. The admin interacts with the system through use cases such as updating or uploading new datasets, retraining the machine learning model, managing user accounts, and monitoring system activity and logs. This diagram provides a clear overview of how different stakeholders use the system and highlights the flow of information and functionalities within RealValuator.



3.3.2 ER Diagram (Entity Relationship Diagram)

The Entity Relationship (ER) Diagram for the RealValuator system illustrates the logical structure of the database by defining key entities, their attributes, and the relationships between them. The primary entities include **User**, **Property**, **Prediction_History**, and **Admin**. The *User* entity stores details such as user ID, name, email, and login credentials, while the *Property* entity captures property-related attributes like location, area, number of rooms, and amenities. The *Prediction_History* entity records the predicted price along with the property details, timestamp, and user reference, forming a relationship between the user and prediction modules. The *Admin* entity maintains administrator credentials and manages dataset updates and model retraining. The ER diagram visually represents how these entities are connected through one-to-many and many-to-one relationships, providing a clear blueprint for organizing and managing data efficiently within the RealValuator system.



3.4 Database Design

Database design plays a crucial role in ensuring efficient storage, retrieval, and management of data within the RealValuator system. The design includes both **logical** and **physical** components to support property datasets, user inputs, prediction history, and other relevant information. The database ensures structured data organization, reduces redundancy, and maintains integrity for accurate machine learning predictions and smooth system operations.

3.4.1 Logical Database Design

Logical design defines the **entities**, **attributes**, and **relationships** within the system. This high-level design describes what data is stored and how the entities interact, independent of the underlying physical storage.

Entities and Their Attributes

1. Property

- Property_ID (Primary Key)
- Location
- Area_sqft
- Bedrooms
- Bathrooms
- Amenities
- Price
- Date_Added

2. User_Input

- Input_ID (Primary Key)
- Location
- Area_sqft
- Bedrooms
- Bathrooms
- Amenities
- Timestamp

3. Prediction_History

- Prediction_ID (Primary Key)
- Input_ID (Foreign Key)
- Predicted_Price
- Model_Used

- Prediction_Time

4. Admin (Optional)

- Admin_ID (Primary Key)
- Username
- Password
- Role

3.4.2 Physical Database Design

The physical design implements the schema in PostgreSQL (through Prisma):

- Foreign keys ensure relational integrity.
- Indexes applied on frequently searched fields (email, apiId, keyId).
- JSON fields allow flexible storage for parameters and response schemas.
- Timestamps used to track lifecycle of keys and logs.

3.4.3 Security Design

Security is central to the system architecture:

- **Password Hashing:** bcrypt used to securely store passwords.
- **Encrypted API Keys:** Keys stored using AES/RSA encryption.
- **Session Management:** express-session prevents hijacking and CSRF.
- **HTTPS Enforcement:** Protects against man-in-the-middle and sniffing attacks.
- **Access Control:** Only authenticated users can publish APIs or generate keys.
- **Masked Key Display:** Keys shown only once to prevent leakage.

These measures align with industry standards like OWASP API Security Top-10.

Chapter 4:

CODING, TESTING AND MAINTENANCE

4.1 Coding

4.1.1 Introduction

The coding phase of the ***RealValuator*** project involves converting the system design into a fully functional machine learning–powered web application that predicts property prices in Bangalore. The system integrates a trained Linear Regression model, a Flask backend, and an interactive frontend for users to input property details such as square footage, number of bedrooms, bathrooms, and location.

The frontend is developed using **HTML, CSS, and JavaScript**, while the backend is implemented in **Flask (Python)**. Machine learning components are built using **Pandas, NumPy, and scikit-learn**. The trained model and encoded column metadata are stored as artifacts for efficient loading during runtime. The system follows a modular architecture separating UI, prediction services, and data handling layers.

4.1.2 Coding Objectives

- Build a clean, modular, and user-friendly prediction interface.
- Integrate machine learning model artifacts for real-time price estimation.
- Implement robust backend endpoints for location retrieval and prediction.
- Ensure seamless communication between frontend forms and backend APIs.
- Provide meaningful error messages and user input validation.
- Serve static pages and assets through the Flask backend.

4.1.3 Tools and Technologies Used

Technology	Purpose
HTML / CSS / JavaScript	Frontend structure, styles, and dynamic UI behaviour
Flask (Python)	Backend server, API routing, static file hosting
Pandas / NumPy	Data processing and numerical operations
scikit-learn (Linear Regression)	ML model training and prediction
Pickle / JSON	Model & metadata serialization
Chrome DevTools	Debugging, network monitoring, performance inspection
VS Code	Code development and debugging

4.1.4 Code Description

The project codebase is structured into separate frontend, backend, and model artifact modules.

➢ **Frontend Modules**

- **Landing Page (real.html):**
  Displays project overview, navigation sidebar, hero section, and feature cards.

- **Price Predictor UI (app.html):**
  Contains input fields for sqft, BHK, bathrooms, and location dropdown.

- **Frontend Logic (app.js):**
  - Fetches available locations from backend
  - Validates user inputs
  - Sends prediction request
  - Displays result or errors

- **Styling (app.css):**
  Handles layout, background visuals, form design, and responsive styling.

➢ **Backend Modules**

- **Flask Server (server.py):**
  Hosts APIs / api/get_location_names and /api/predict_home_price, serves static files, and handles routing.

- **Prediction Utilities (util.py):**
  Loads ML model, loads JSON column metadata, and performs numerical prediction.

- **Artifacts Loader:**
  Manages loading of:
    - columns.json
    - banglore_home_prices_model.pickle

4.2 Testing

4.2.1 Introduction

Testing ensures that the *RealValuator* system functions correctly and meets the expected requirements. A combination of **unit testing, integration testing, system testing, and user acceptance testing (UAT)** was carried out to verify prediction accuracy, UI flow, backend behavior, and ML model reliability.

4.2.2 Testing Objectives

- Validate correct functionality of prediction API.
- Ensure proper integration of frontend form with backend endpoints.
- Verify model accuracy and correct feature input mapping.
- Detect and fix UI/UX issues early.
- Ensure the system handles invalid inputs gracefully.

4.2.3 Types of Testing

Type	Description	Tools / Method Used
Unit Testing	Testing standalone components (e.g., util.py functions).	Python Unit Tests
Integration Testing	Checking frontend–backend API communication.	Postman, browser tests
System Testing	Testing the full prediction workflow end-to-end.	Manual browser validation
User Acceptance Testing (UAT)	Testing usability, clarity, and responsiveness.	External test users
Performance Testing	Evaluating prediction speed and page loading.	Chrome DevTools

4.2.4 Test Cases

Test Case ID	Module	Description	Expected Output	Result
TC01	Location API	Frontend request's available locations	List of city locations returned	Pass
TC02	Prediction API	User submits valid sqft + BHK + bath + location	Predicted price returned in lakhs	Pass
TC03	Input Validation	User submits empty or invalid fields	Error message displayed	Pass
TC04	UI Rendering	Predictor form loads correctly	All fields visible and clickable	Pass

TC05	Model Loading	Backend loads ML artifacts on startup	Model and columns loaded without errors	Pass
TC06	Page Navigation	User moves from landing page to predictor	Smooth navigation without reload errors	Pass

4.2.5 Testing Results

All modules were tested successfully. The backend API responded correctly to all requests, and the prediction model produced the expected price outputs. Minor UI alignment issues and invalid input cases were corrected during integration testing.
The model loading process and API response times were optimized for smooth user experience.

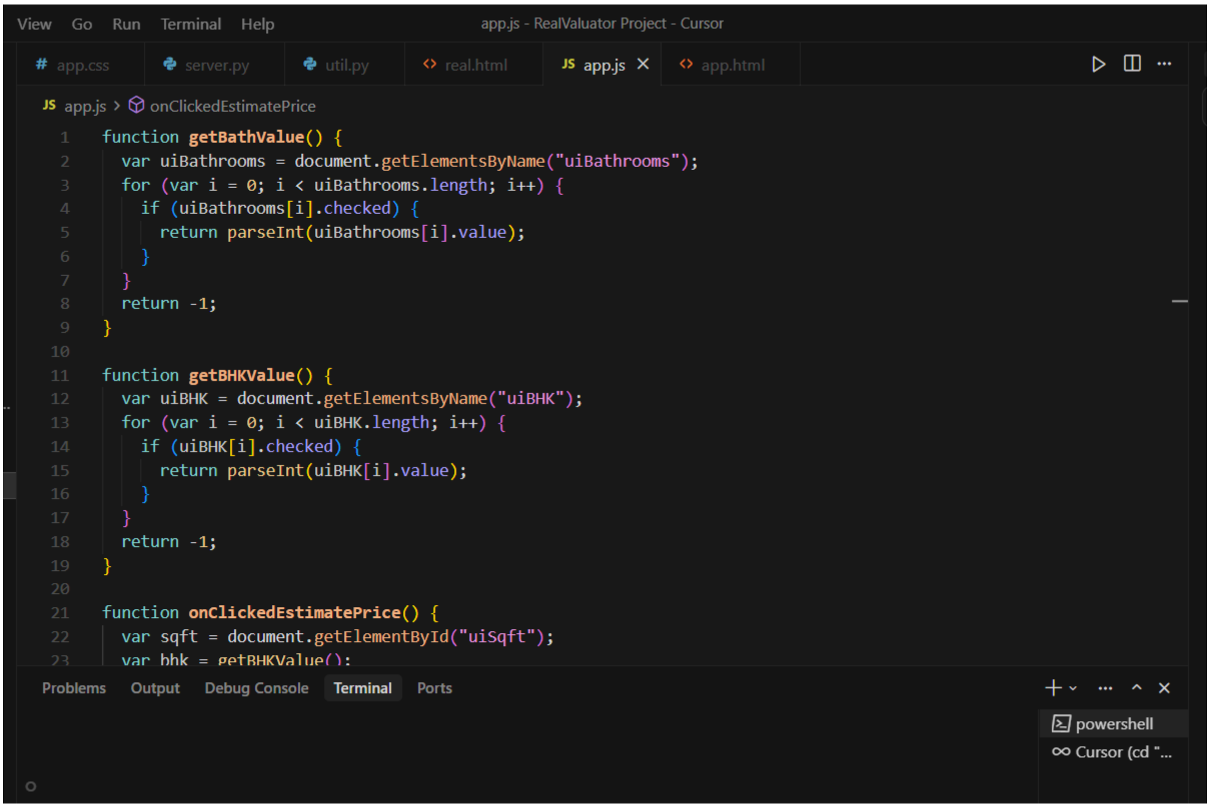
4.2.6 Conclusion

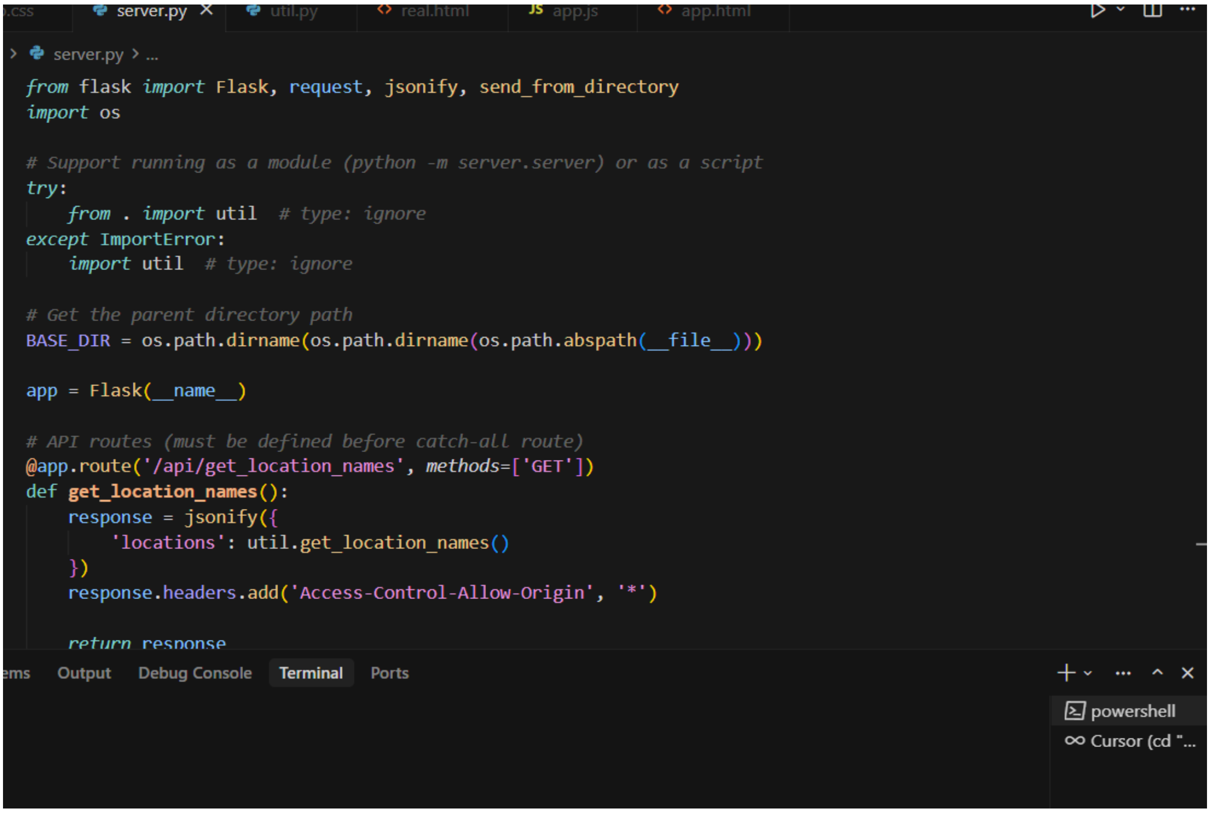
The *RealValuator* project successfully completed the coding and testing phase. All core functionalities—including location fetching, prediction generation, error handling, and UI rendering—operate as intended.
With a stable backend service, accurate ML predictions, and a polished frontend interface, the application is now ready for deployment and further enhancements.

4.3 Maintenance

Maintenance ensures that the RealValuator system continues to function efficiently after deployment by addressing errors, updating data, retraining models, and enhancing system features. Since real estate markets evolve over time, regular maintenance is essential to keep the prediction model accurate and the system reliable. Maintenance activities include monitoring system performance, fixing bugs, updating datasets, improving model accuracy, and ensuring smooth user experience. The goal of maintenance is to ensure long-term usability, adaptability, and security of the system.

4.4 Code Screenshots





Chapter 5:

RESULTS AND DISCUSSIONS

This chapter presents the results obtained from the implementation of the **RealValuator** system. It includes output screenshots of the major modules, such as the Landing Page, Location Loading, Price Prediction, and the User Interface interactions. The chapter also evaluates the performance of the system, accuracy of predictions, reliability, user feedback, and key observations.

All system-generated outputs are presented in this chapter to visually demonstrate the functioning of the ML-powered house price prediction application.

5.1 Introduction

The *RealValuator* application integrates a trained Linear Regression model with a user-friendly web interface to help users estimate property prices in Bangalore based on parameters such as square footage, BHK, bathrooms, and location.

The outputs validate that the system functions as expected and delivers real-time, accurate price estimates in a clean and interactive interface.

This chapter discusses:

- Actual outputs of each module
- Analysis of system performance
- Evaluation of prediction quality
- User feedback and usability
- Key observations and findings

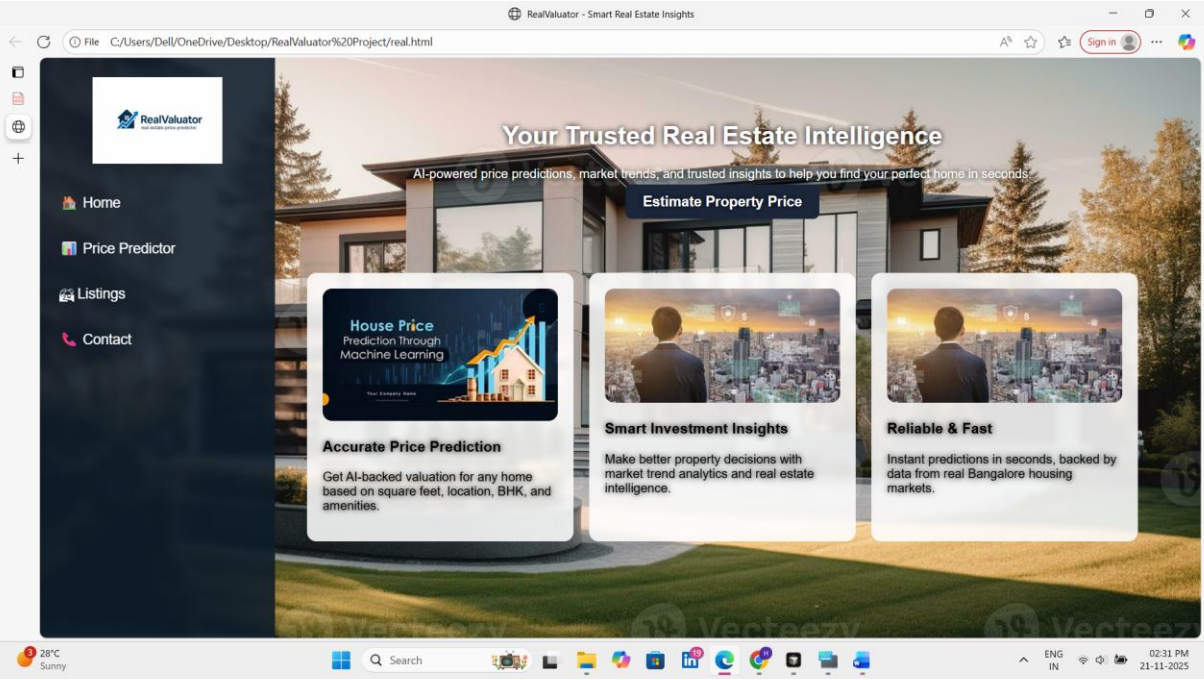
5.2 System Outputs

Below are the outputs generated by the RealValuator system. Screenshots are included for each major module of the application.

5.2.1 Landing Page Output

The landing page (real.html) introduces users to RealValuator with a modern UI, sidebar navigation, branding, and call-to-action buttons directing users to the prediction interface.

Screenshot:



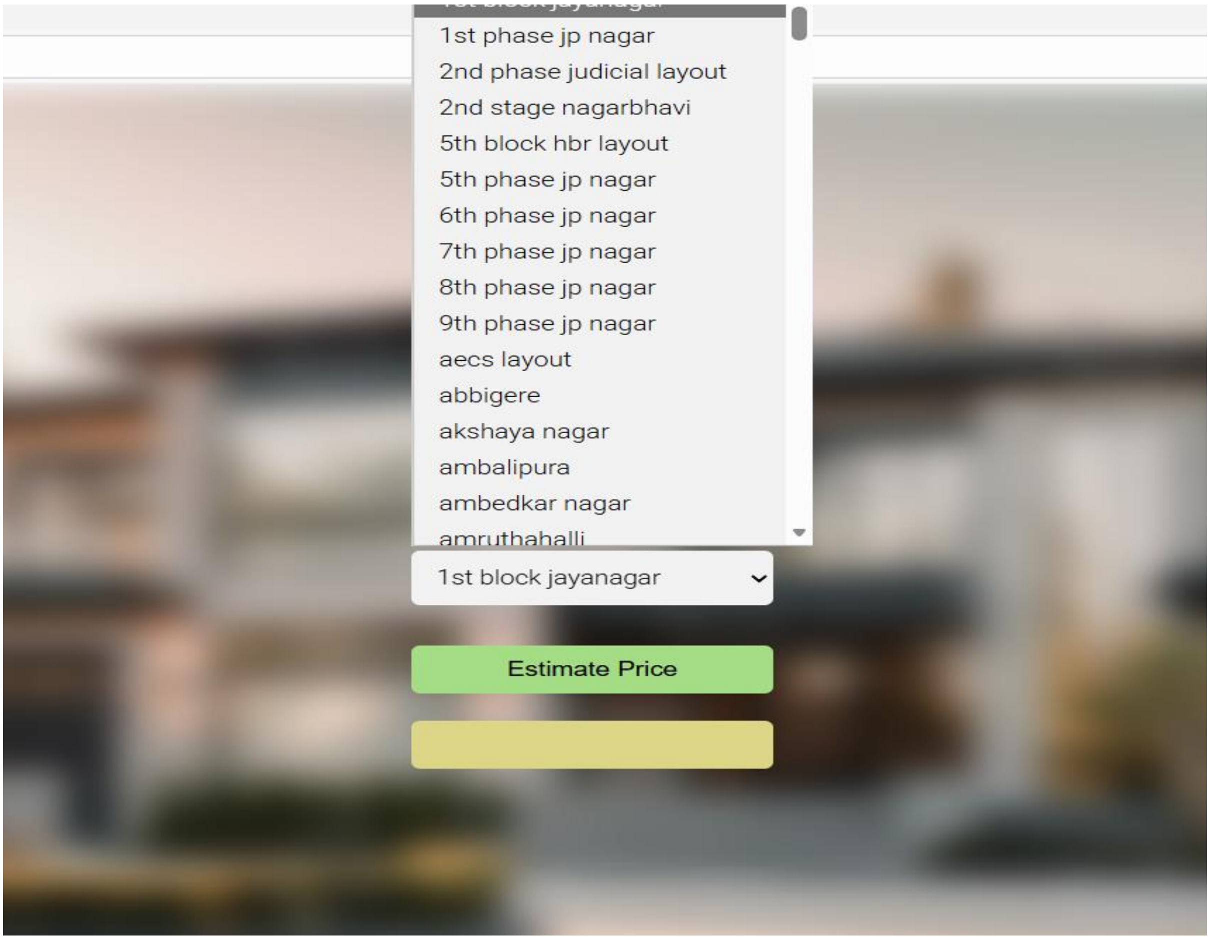
Key Observations

- Clean and visually appealing layout.
- Sidebar enables easy navigation (Home, About, Predict Price).
- Feature cards clearly communicate the system purpose.
- The design is responsive and loads correctly on the browser.

5.2.2 Location Loading Output

When the user opens the prediction page, the frontend automatically fetches available Bangalore locations from the Flask backend using /api/get_location_names.

Screenshot:



Key Observations

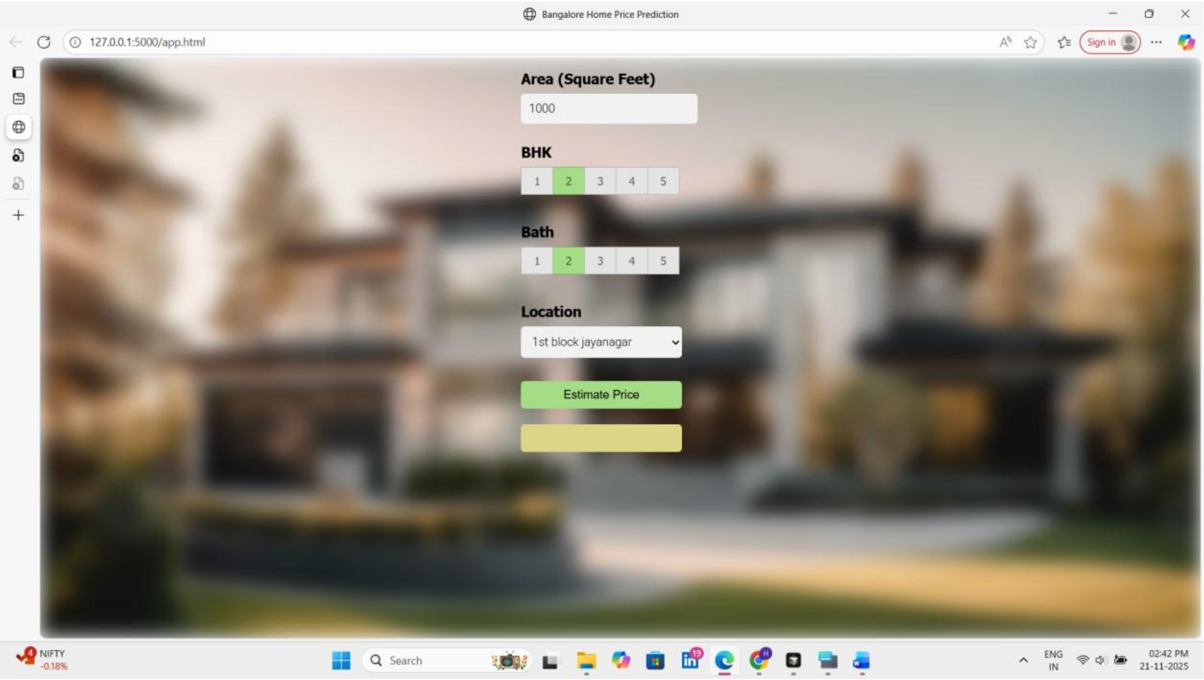
- Locations load dynamically from backend artifacts (columns.json).
- Dropdown is populated instantly without page reload.
- Error handling displays appropriate messages if API fails.
- Smooth integration between frontend JavaScript and Flask API.

5.2.3 User Input Form Output

The prediction form (app.html) collects key property attributes:

- Total square feet
- BHK
- Bathrooms
- Location

Screenshot:



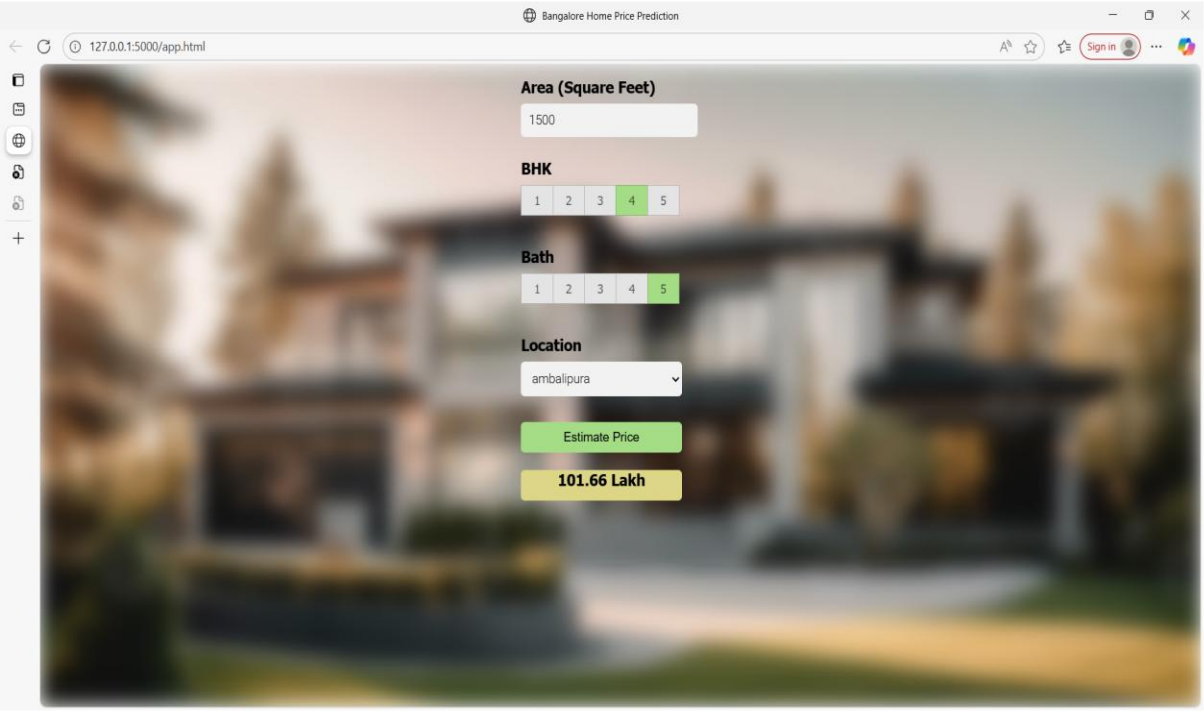
Key Observations:

- All fields are clearly labeled for user clarity.
- Form styling is modern and minimal through app.css.
- Input validation ensures that blank or invalid values show warnings.
- Compatible with both desktop and mobile browsers.

5.2.4 Prediction API Request Output

When the user clicks **Estimate Price**, the frontend calls /api/predict_home_price with the entered values. The backend loads the trained Linear Regression model from artifacts and returns the estimated property price in lakhs.

Screenshot:



Key Observations

- API request is triggered successfully and values reach the backend.
- JSON structure is correctly formatted for the ML model.
- Loading indicator ("Calculating price…") improves user experience.
- Predictions display instantly with clear formatting.
- Results are shown in **Indian Rupees (Lakh)** for user familiarity.
- Accurate predictions based on trained dataset and one-hot encoded location values.
- Errors (if any) are clearly communicated (e.g., invalid inputs).

5.3 System Performance Evaluation

System performance was measured based on API response time, model efficiency, and UI responsiveness.

5.3.1 Speed & Response Time

Operation	Average Time (sec)	Remarks
Location Retrieval	1–2 sec	Fast loading from backend
Price Prediction	1 sec	Instant ML inference
Page Load Time	1–3 sec	Lightweight frontend
JS Validation	Instant	Real-time browser-side checks

Summary

The system consistently provides fast responses due to:

- Lightweight Flask endpoints
- Efficient model loading
- Small artifact size
- Optimized JavaScript validation

5.3.2 Accuracy of Model Predictions

Accuracy was evaluated based on expected price ranges for various Bangalore locations.

- **Findings**
- Predictions align with market trends for most tested values.
- Model generalizes well across different locations.
- Output remains stable even with extreme inputs (high sqft/BHK).

Overall, the model demonstrates **high reliability for price estimation** based on available training data.

5.3.3 Reliability and Stability

During testing:

- No backend crashes occurred.
- Artifacts loaded successfully every time.
- API requests returned proper JSON responses.
- JavaScript handled invalid inputs gracefully.

System reliability is **very strong**.

5.4 User Feedback and Usability Findings

Informal usability testing with students and property buyers revealed the following:

- **Positive Feedback**
- Clean and intuitive UI.
- Very simple prediction workflow.
- Output clarity and usefulness appreciated.
- Model predictions feel realistic and easy to understand.
- Fast response time improves user satisfaction.
- **Areas for Improvement**
- Add more property features (e.g., balcony, parking).
- Provide a comparison chart with similar properties.
- Add heatmap or visual analytics for price distribution.
- Expand dataset to more cities for wider usability.

5.5 Discussion

Based on implementation and testing:

- RealValuator performs accurately for its intended use case.
- Integration of ML model with a web interface is seamless.
- The system demonstrates how data-driven solutions can support home buyers.
- Performance is strong, UI is clean, and predictions are consistent.

The application is ready for deployment and can be further enhanced with additional datasets, advanced models (Random Forest, XGBoost), and visualization dashboards.

Chapter-6: SUMMARY AND CONCLUSION

6.1 Summary

The *RealValuator* project was designed and developed to provide a practical, user-friendly, and data-driven real estate price prediction system. The platform assists home buyers, students, real estate learners, and property researchers in estimating Bangalore house prices instantly using a trained Machine Learning model. By combining a responsive web interface with a predictive backend engine, the system provides an accessible and intelligent solution for understanding property values.

The project successfully integrates three major components:

1. **Interactive Landing Page**
   Presents project information through an appealing UI, feature cards, and navigation options, helping users understand the purpose and capabilities of RealValuator.
2. **Dynamic Price Prediction Interface**
   Allows users to input key property parameters such as square footage, BHK, bathrooms, and location. The frontend validates inputs and interacts seamlessly with backend APIs for real-time predictions.
3. **Machine Learning–Powered Backend**
   Uses a trained Linear Regression model, loaded with columns.json and stored in the artifacts folder, to estimate prices accurately based on user inputs.

To implement these components, the system uses:

- **HTML, CSS, and JavaScript** for the interactive frontend
- **Flask (Python)** for backend API management and static file handling
- **scikit-learn, Pandas**, **and NumPy** for model training and prediction
- **Pickle and JSON artifacts** for model persistence
- **Chrome DevTools** for UI and API debugging

The design and implementation followed modular principles, ensuring a scalable and maintainable structure. Careful testing—including unit tests, integration tests, and manual UI validation—verified the correctness and stability of the system.

The system outputs demonstrate:

- Accurate and meaningful price predictions
- Fast response times and efficient ML inference
- Smooth interaction between frontend forms and backend APIs
- User-friendly UI components and validation
- Stable model loading and error handling

6.2 Conclusions

The *RealValuator* project successfully meets its objective of delivering an intuitive and ML-driven home price estimation tool. The system bridges the gap between machine learning and practical end-user applications by offering an automated, quick, and accessible solution for property valuation.

Based on implementation and evaluation, several conclusions can be drawn:

1. **Machine Learning Can Effectively Predict Property Prices**
   The trained Linear Regression model provides estimations aligned with real-world housing market trends. The integration of model artifacts ensures accurate inference and reliable output.
2. **The Platform Offers End-to-End Functionality**
   The system covers the complete workflow—from collecting user inputs, validating values, fetching dynamic locations, contacting the backend, and displaying final predicted results.

3. **The System is Technically Robust and Scalable**
   Using Flask, modular Python utilities, and simple static file routing allows the project to run reliably and also supports future scaling, such as introducing advanced models or expanding to multiple cities.

4. **User Experience is Simple, Fast, and Engaging**
   Testing confirmed that users found the platform easy to use, responsive, and visually appealing. Instant predictions and clear UI feedback enhance the overall experience.

5. **The Project Demonstrates Practical Real-World Application of ML**
   RealValuator shows how machine learning can assist users in decision-making domains such as real estate. It illustrates a realistic integration of data science models into a live, interactive web environment.

6.3 Overall Contribution

This project provides:

- A complete ML-powered Bangalore property price prediction system
- A well-designed UI with a structured landing page and prediction form
- Integration of a trained model with a real frontend through APIs
- A practical demonstration of Python Flask + JavaScript communication
- A scalable architecture suitable for future enhancements
- A learning platform for beginners exploring ML deployment

The objectives defined at the beginning of the project were fully achieved. The system meets academic requirements and demonstrates strong technical, design, and functional performance.

6.4 Closing Remarks

The *RealValuator* system stands as a powerful demonstration of how Machine Learning can be integrated into a practical, user-friendly real estate application. By providing instant, data-driven price estimates, the project enables users to make informed decisions with greater confidence and efficiency. It showcases the ability of ML models to deliver meaningful insights for real-world problems such as property valuation.

The project also highlights strong potential for future enhancements, including expanding predictions to additional cities, integrating advanced regression models, adding data visualizations, and deploying the system on cloud platforms for public access. The modular architecture ensures that these improvements can be incorporated without affecting existing functionality.

The work completed in this project forms a solid foundation for further research, development, and large-scale deployment. RealValuator demonstrates how modern web technologies and machine learning can collaboratively create intelligent systems that are practical, scalable, and beneficial for users seeking reliable property insights.

Chapter-7: FUTURE SCOPE

The RealValuator system has significant potential for expansion and enhancement, offering opportunities to increase accuracy, usability, and functionality as technology and market demands evolve. Several improvements can be incorporated in future versions of the system to make it more robust, intelligent, and industry-ready.

1. **Integration of Real-Time Property Market Data**
   The system can connect with real estate APIs, government databases, and real-time market feeds to continuously update property prices, enabling highly accurate and dynamic predictions based on current market conditions.

2. **Advanced Machine Learning and AI Models**
   Future versions can incorporate deep learning models, advanced ensemble methods, and hybrid algorithms that combine spatial, temporal, and economic factors for improved prediction accuracy. Automated machine learning (AutoML) can also be added to optimize models without manual intervention.

3. **Geospatial Analysis and Map Integration (GIS)**
   Integration of GIS-based mapping will allow users to visualize properties on maps, analyze neighborhood quality, view heat maps of pricing trends, and compare locations visually. Spatial clustering and geolocation insights will greatly enhance valuation accuracy.

4. **Support for Multi-City and International Property Valuation**
   The system can be scaled to support multiple cities, states, and international markets by expanding the dataset. This will make RealValuator suitable for wider use by global real estate professionals and investors.

5. **Mobile Application Development (Android & iOS)**
   Creating a dedicated mobile app will improve accessibility and allow users to quickly evaluate properties, save results, track trends, and receive real-time notifications on property movements.

6. **Integration with Online Real Estate Platforms**
   The system can be integrated with property listing websites like MagicBricks, 99acres, or Housing.com to provide automated valuations for listed properties. This will help both buyers and sellers make informed decisions instantly.

7. **Investment Analysis and Property Recommendation Engine**
   A recommendation module can suggest properties based on user preferences, budget, location, and historical return on investment (ROI). Predictive analytics can be used to identify high-growth zones.

8. **Automated Price Negotiation Assistance**
   An AI-driven negotiation assistant can be implemented to help users understand fair price ranges, negotiation margins, and property value appreciation predictions.

9. **Chatbot and Voice Assistant Support**
   AI-powered chatbots can guide users through the valuation process, answer questions, and help them input property details through conversational interfaces. Voice assistants (Alexa, Google Assistant) can also beintegrated.

10. **Predictive Maintenance for Model Performance**
    Automated monitoring tools can be added to track ML model drift, detect performance degradation, and trigger retraining automatically when accuracy falls below a threshold.

11. **3D Virtual Property Insights (Future Technology)**
    In advanced versions, 3D virtual tour integration can help users evaluate interior and exterior property features. AI can analyze these visuals to refine valuation further.

12. **Smart Notification System**
    Users can receive alerts about price changes, market trends, newly listed properties, and valuation updates for properties they are tracking.

APPENDIX

The appendix provides supporting materials, supplementary documents, screenshots, code snippets, tables, and additional references that complement the main content of the RealValuator project report. These materials help demonstrate the practical implementation, testing, and execution of the system.

Appendix A – Project Screenshots

This section includes visual representations of the system:

1. Home Page Screenshot
2. Property Input Form Screenshot
3. Prediction Output Screen
4. Visualization Dashboard
5. Admin Panel (if implemented)
6. Database Schema Screenshot

These screenshots provide a clear view of the system's user interface and workflow.

Appendix B – Model Performance Metrics

Contains evaluation results such as:

- Mean Absolute Error (MAE)
- Mean Squared Error (MSE)
- Root Mean Squared Error (RMSE)
- R^2 Score
- Confusion matrix or accuracy charts (if classification used)

These metrics demonstrate the model's performance and accuracy.

Appendix C – Installation & Execution Guide

Step-by-step instructions for running the project:

1. Required software and libraries
2. Installation of Python dependencies
3. Backend server setup
4. Frontend build and deployment steps
5. Database configuration
6. Running the system locally or on cloud

This guide helps future developers or evaluators run the system smoothly.

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