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INTELLIGENT PROPERTY RECOMMENDATION SYSTEM FOR AFFORDABLE AND SUSTAINABLE HOUSING CHOICES

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A Hybrid Machine Learning and Knowledge-Based Reasoning Project Collaborative Final Project
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Abstract

The **Intelligent Property Recommendation System for Affordable and Sustainable Housing Choices** is a hybrid platform that combines **Machine Learning (ML)** and **Knowledge Representation and Reasoning (KRR)** techniques to assist users in finding suitable housing options in the Philippines. The system addresses the challenges of navigating overwhelming real estate listings by providing **personalized recommendations** based on user preferences such as budget, location, property type, number of bedrooms, and amenities.

The ML component employs **content-based recommendation** using **TF-IDF vectorization** and **cosine similarity** to match user input with property descriptions and locations. Additionally, a **Random Forest Regressor** predicts current and future property prices, allowing users to plan for long-term investments. The KRR component applies **rule-based reasoning** to ensure that recommendations meet **affordability criteria, sustainability standards, and user-specific preferences**, offering explainable AI insights to guide informed decision-making.

By integrating both ML and KRR, the system provides a **robust, scalable, and explainable** framework for property recommendation. Users receive a ranked list of properties with sustainability tags and projected price trends, supporting smarter housing decisions. This system contributes to **Sustainable Development Goal 11 (Sustainable Cities and Communities)** by promoting equitable access to affordable housing, highlighting eco-friendly properties, and aiding in urban planning decisions.

Keywords: Intelligent Property Recommendation System, Machine Learning, Knowledge Representation and Reasoning, Content-Based Recommendation, TF-IDF, Cosine Similarity, Random Forest Regression, Future Price Prediction, Sustainable Housing, Affordable Housing, Explainable AI, Philippine Real Estate, SDG 11 – Sustainable Cities and Communities

I. PROJECT OVERVIEW

The Intelligent Property Recommendation System is a hybrid platform combining **Machine Learning (ML)** and **Knowledge Representation and Reasoning (KRR)** techniques to provide users with personalized housing recommendations. This system aims to assist prospective homebuyers in finding **affordable, well-located, and sustainable properties** in the Philippines.

The system leverages **user input** such as budget, preferred location, property type, number of bedrooms, and other amenities. Using **textual descriptions** from listings and **structured property data**, the ML component identifies the most relevant properties, while the KRR rules ensure that only properties that meet **sustainability, affordability, and user preference criteria** are highlighted. Additionally, the system predicts **future property prices**, allowing users to plan for long-term investments ranging from 1 to 10 years or more.

This system directly contributes to **SDG 11: Sustainable Cities and Communities**, by supporting equitable access to housing, promoting environmentally friendly features, and assisting in urban planning decisions.

II. OBJECTIVES

General Objective:

To design and implement a hybrid recommendation system that assists users in discovering suitable housing options tailored to their financial and lifestyle preferences, while also providing future price projections and sustainability insights.

Specific Objectives:

- Enable users to input property preferences (budget, location, property type, number of bedrooms, amenities) via a web interface or API.
- Utilize a **content-based recommendation model** using textual property descriptions to find the most relevant housing options.
- Incorporate **rule-based reasoning** to evaluate affordability, sustainability, and alignment with user priorities.
- Predict **future property prices** based on historical trends and user-defined investment horizons.
- Provide **explainable AI insights** to users, showing why a particular property was recommended.

III. SYSTEM ARCHITECTURE

Flow of System:

User Input → Machine Learning Recommendation Model → KRR Filtering Rules → Future Price Prediction → Final Recommendations

Description:

1. **User Input:** Users enter property preferences (location, category, budget, bedrooms, bathrooms, floor area, land size).
2. **ML Recommendation:** The system converts textual descriptions of all properties into numeric feature vectors using **TF-IDF**, then calculates **cosine similarity** between user input and each listing.
3. **KRR Rules:** Properties are filtered using **rule-based criteria**: affordability, eco-friendly features, proximity to key facilities, number of bedrooms, and property type.
4. **Future Price Estimation:** For each recommended property, the system calculates future price projections using a **Random Forest Regressor** and user-specified years, considering an annual growth rate.
5. **Final Recommendations:** Properties are ranked based on relevance, affordability, sustainability score, and projected price growth.

IV. MACHINE LEARNING COMPONENT

Algorithms Used:

- **TF-IDF Vectorization + Cosine Similarity**: For content-based recommendation based on property descriptions and locations.
- **Random Forest Regressor**: For predicting property prices and projecting future values.

Dataset Size: Approximately 5000 real estate listings from various Philippine locations.

Model Accuracy:

- Random Forest Regression achieved approximately **R^2 ~ 90%** on the test set, providing reliable price predictions (subject to refinement with larger datasets).

V. MACHINE LEARNING PIPELINE

1. Data Collection:

- Property data sourced from online real estate listings, partner agents, and synthetic data for testing personalization.

- Columns include: description, location, bathrooms, bedrooms, car_spaces, floor_area_sqm, land_size_sqm, price, and category.

2. Data Preprocessing:

- Combined description and location into a single text field for TF-IDF processing.
- Removed English stopwords and limited the vocabulary to 5000 terms for efficient feature extraction.
- Standardized numerical features (e.g., bedrooms, bathrooms, floor area) to feed the regression model.

3. Model Training:

- **Random Forest Regressor** trained on numerical features to predict property prices.
- TF-IDF vectors used for computing similarity between user input and property listings.

4. Model Evaluation:

- Dataset split into 80% training and 20% testing.
- Performance metrics: R^2 score, RMSE for regression, and precision of top N recommendations.

5. Model Deployment:

- Python implementation via **Google Colab** for experimentation.
- Functions available for filtering properties by category, budget, and bedrooms.
- Integrated pipeline allows both **recommendation** and **future price forecasting** in a single workflow.

VI. DATASET DESCRIPTION

Dataset Type: Mixed text and structured numeric real estate data.
Number of Records: 5000+ listings (example dataset).
Target Variable: price (in Philippine Pesos).
Features Used: description, location, bedrooms, bathrooms, car_spaces, floor_area_sqm, land_size_sqm, category.

VII. KNOWLEDGE REPRESENATION AND REASONING

Rule-Based Reasoning:

Rule 1: IF property_price ≤ user_budget THEN include property in recommendation list.
Rule 2: IF distance_to_key_facilities ≤ threshold THEN include property.
Rule 3: IF eco_friendly_features exist THEN tag property as "sustainable choice."
Rule 4: IF number_of_bedrooms ≥ user_preference THEN retain property.
Rule 5: IF property_category = user_selected_category THEN retain property.

Explanation:
These rules allow the system to provide **explainable recommendations** that go beyond simple ML similarity scores. Users can see why a property is suitable based on affordability, sustainability, and preference alignment.

VIII. HYBRID DECISION LOGIC

- ML identifies the **most relevant properties** based on textual and numeric similarity.
- KRR applies **domain knowledge** rules to filter or tag properties as sustainable, affordable, and matching user preferences.
- Future prices are predicted using a **Random Forest Regressor**, considering annual growth rates, giving users a **long-term investment perspective**.

IX. SYSTEM FEATURES

☑ **Personalized property recommendations** based on textual description, location, and numeric property attributes.

☑ **Rule-based filtering** for sustainability and affordability.

☑ **Future price forecasting** for 1–10 years.

☑ **Web interface / API** for easy user input.

☑ **Google Colab deployment** for demonstration and model testing.

☑ **Explainable AI** insights showing why properties were recommended.

X. TESTING AND EVALUATION

Test Case	Input Summary	Expected Output
1	User searches for a 3-bedroom condo ≤ ₱3,000,000 in Makati	Top 5 condos matching budget and bedroom requirement, showing sustainability tags and projected future prices
2	User wants 10-year price projection	Selected property, years=10 → Projected price using Random Forest model and 5% annual growth rate
3	User selects “eco-friendly” category	Only properties with eco-friendly features are displayed
4	User searches with category and budget	Properties filtered by both user budget and selected category, ranked by relevance

XI. CONCLUSION

The **Intelligent Property Recommendation System** successfully integrates **Machine Learning and Knowledge-Based Reasoning** to address challenges in the Philippine real estate market. It reduces the burden of searching for affordable and sustainable housing, provides **explainable insights**, and assists users in making informed long-term investment decisions. By predicting future prices and highlighting eco-friendly options, the system contributes to **inclusive, sustainable, and safe urban living**, aligning with **SDG 11**.

Member Name	Contribution
Ramos, Jezreel R.	ML model development, TF-IDF recommendation pipeline, cosine similarity computation, Data processing, Rules implementation, UI design, and documentation.
Capili, Judeelyn M.	Dataset preprocessing, feature engineering, regression model evaluation, future price prediction
Avellaneda, Shaila Patrice D.	KRR rules implementation, system integration, user interface design, project documentation

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