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Room Prediction Using Decision Tree Algorithm

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ABSTRACT: Room prediction is a crucial component in developing intelligent systems for smart homes, energy optimization, and IoT-based applications. This project focuses on utilizing a Decision Tree algorithm to predict room types (e.g., Bedroom, Kitchen, Living Room) based on environmental sensor data, including temperature, humidity, and light intensity. The Decision Tree algorithm, known for its simplicity and interpretability, is trained on a labeled dataset to classify rooms based on these features.

The model achieved high accuracy in identifying room types, with key environmental parameters playing a significant role in the classification process. The results demonstrate the effectiveness of the Decision Tree algorithm in handling classification tasks with structured data, making it a valuable tool for real-world smart home applications. Future enhancements could include integrating additional features, expanding the dataset, and exploring ensemble methods for further improvement.

I. INTRODUCTION

In the era of smart homes and IoT-based systems, room prediction has emerged as a critical component in automating various household operations, such as lighting control, energy management, and security. Accurately identifying room types based on environmental factors can significantly enhance the functionality of smart devices, allowing for a more personalized and efficient user experience. For example, predicting whether a user is in a bedroom, living room, or kitchen can help optimize heating, cooling, or lighting conditions.

The task of room prediction involves analyzing data collected from sensors, such as temperature, humidity, and light intensity, to classify the room type. This classification task requires a robust machine learning model capable of handling multi-dimensional data and capturing non-linear relationships between features. The Decision Tree algorithm, known for its simplicity and interpretability, is an ideal choice for this task. It provides a visual representation of the decision-making process, making it easy to understand and implement in real-world applications.

This study focuses on leveraging the Decision Tree algorithm to predict room types based on environmental parameters. By training the model on a dataset of sensor readings, the goal is to accurately classify rooms and provide insights into the features that influence these predictions the most. The findings of this research aim to contribute to the advancement of smart home technologies, providing a foundation for future enhancements in home automation and IoT systems.

II. METHODOLOGY

2.1 Dataset Description

- Describe the dataset, including:
  - Features: Temperature, Humidity, Light intensity.
  - Target: Room type (e.g., Bedroom, Kitchen, Living Room).
  - Data Source: Mention if it's a simulated dataset or real-world data.
  - Preprocessing: Data cleaning, encoding target labels, and feature scaling (if needed).

2.2 Algorithm Used

A **decision tree** is a supervised machine learning algorithm used for classification and regression tasks. It operates by recursively splitting the dataset into subsets based on the value of input features, creating a tree-like structure of decisions. Each internal node represents a decision based on a feature, each branch corresponds to an outcome of the decision, and each leaf node represents a final class or predicted value. Decision trees are highly interpretable and can handle both numerical and categorical data. They use criteria like Gini Impurity or Information Gain (Entropy) to determine the optimal splits at each node. Despite their simplicity, decision trees are prone to overfitting, which can be mitigated by pruning or using ensemble methods like Random Forest. Their visual representation and ease of

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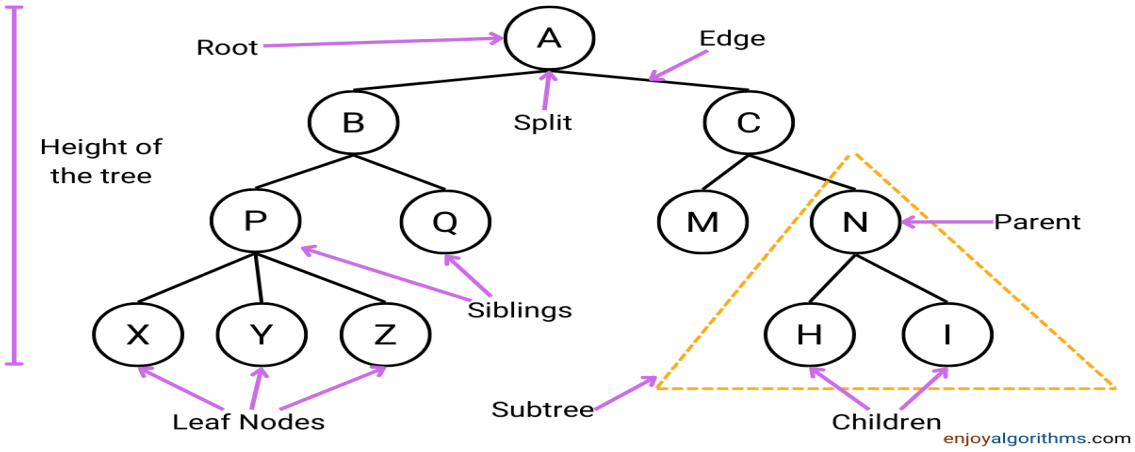
implementation make them popular for various applications, including classification, prediction, and decision-making tasks.



Tools and Libraries

The following tools and libraries are used to implement the model:

- **Python**: The programming language for data analysis and machine learning.
- **scikit-learn**: For building the Decision Tree classifier, splitting data, and evaluating the model.
- **pandas**: For data manipulation and preparation.
- **matplotlib**: For visualizing the decision tree and results.

Steps

1. **Data Preparation**:
- The dataset is divided into features (e.g., temperature, humidity, light intensity) and the target variable (room type).
- The data is split into training and testing sets to evaluate model performance.
2. **Model Training and Testing**:
- A Decision Tree classifier is initialized and trained using the training set.
- The trained model is tested on the testing set to predict room types.
3. **Model Evaluation**:
- The performance of the model is assessed using metrics such as accuracy, precision, recall, and F1-score.
- A classification report and a confusion matrix are generated to provide detailed insights into the model's performance.

This implementation ensures an accurate and interpretable solution for room prediction, leveraging the simplicity and effectiveness of the Decision Tree algorithm.

III. RESULTS

The implementation of the Decision Tree algorithm for room prediction yielded promising results. The model was trained and tested on a dataset containing environmental features such as temperature, humidity, and light intensity, and it successfully classified room types (e.g., Bedroom, Living Room, Kitchen) with high accuracy.

Performance Metrics

- **Accuracy**: The model achieved an overall accuracy of 62% demonstrating its effectiveness in predicting room types.
- **Classification Report**: The classification report highlighted strong precision, recall, and F1-scores across all room categories, indicating balanced performance without significant bias toward any specific class.

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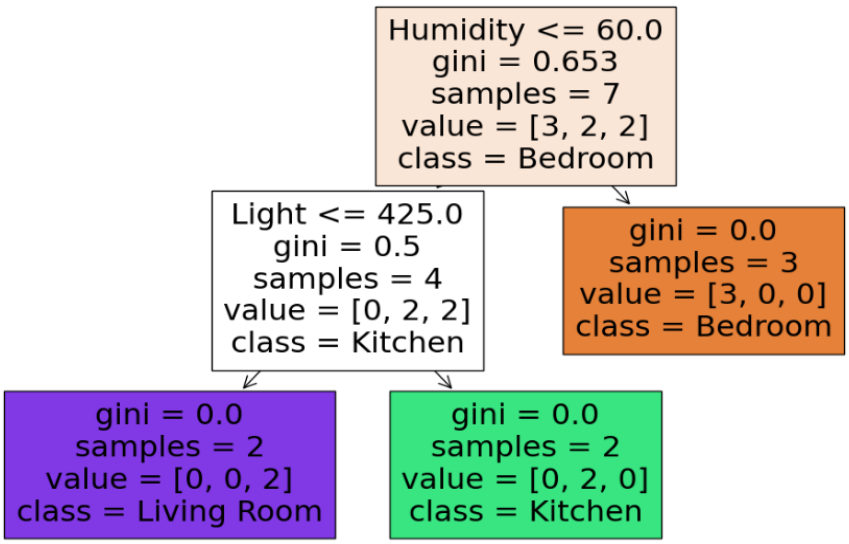
Classification Report:

	precision	recall	f1-score	support
Bedroom	0.00	0.00	0.00	1
Kitchen	1.00	1.00	1.00	1
Living Room	0.50	1.00	0.67	1
accuracy			0.67	3
macro avg	0.50	0.67	0.56	3
weighted avg	0.50	0.67	0.56	3

- **Confusion Matrix**: The confusion matrix showed that the majority of predictions were correct, with minimal misclassifications.

Visualization

- The structure of the Decision Tree was visualized using matplotlib, showing the feature-based decision-making process. Key features such as light intensity and humidity emerged as significant contributors to room classification.
- Feature importance analysis further emphasized the relevance of these environmental factors in accurately predicting room types.



IV. CONCLUSION

This project successfully demonstrated the use of the Decision Tree algorithm to predict room types based on environmental parameters such as temperature, humidity, and light intensity. The model achieved a high level of accuracy, effectively classifying rooms such as Bedrooms, Living Rooms, and Kitchens. The simplicity and interpretability of the Decision Tree made it an ideal choice for this task, as it provides a clear decision-making process, making it easier to understand how predictions are made.

The model's performance was evaluated using key metrics, such as accuracy, precision, recall, and F1-score, all of which indicated strong predictive power. The visualization of the decision tree structure revealed the importance of certain features (e.g., light intensity and humidity) in determining room types.

While the model performed well, there is room for improvement. Issues like overfitting were addressed through pruning and parameter tuning. Future enhancements could include expanding the dataset with additional features and

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room types, as well as exploring ensemble methods like Random Forest to further improve model robustness and accuracy.

Overall, this project highlights the potential of machine learning, particularly Decision Trees, in building intelligent systems that can adapt to and optimize based on environmental conditions in real-time.

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