Experiment Tracking Report: California Housing Price Prediction using MLFlow

Experiment Overview

This experiment focuses on predicting house prices using the California Housing dataset. Two machine learning models, **Linear Regression** and **Random Forest**, were used to predict the target variable (house prices). MLflow was employed for experiment tracking, enabling the logging of metrics and model parameters.

Dataset

- **Dataset Source**: California Housing dataset from sklearn.
- **Target Variable**: `target` (housing prices).
- **Features**:
  - `MedInc`: Median income of households in a block.
  - `HouseAge`: Median age of houses in a block.
  - `AveRooms`: Average number of rooms per household.
  - `AveBedrms`: Average number of bedrooms per household.
  - `Population`: Block population.
  - `AveOccup`: Average number of household members.
  - `Latitude`: Block latitude.
  - `Longitude`: Block longitude.

Objectives

- Compare the performance of Linear Regression and Random Forest Regressor models.
- Track and log metrics such as **Mean Squared Error (MSE)**, **Mean Absolute Error (MAE)**, and **R-squared (R^2)** using MLflow.

Setup

- **Training-Testing Split**: 80% training, 20% testing.
- **Feature Scaling**: Standardization was applied to numerical features using `StandardScaler`.

Models Trained

1. **Linear Regression**
   - A linear model to predict the target variable based on the features.
2. **Random Forest Regressor**
   - An ensemble-based decision tree model that combines multiple trees to make predictions.

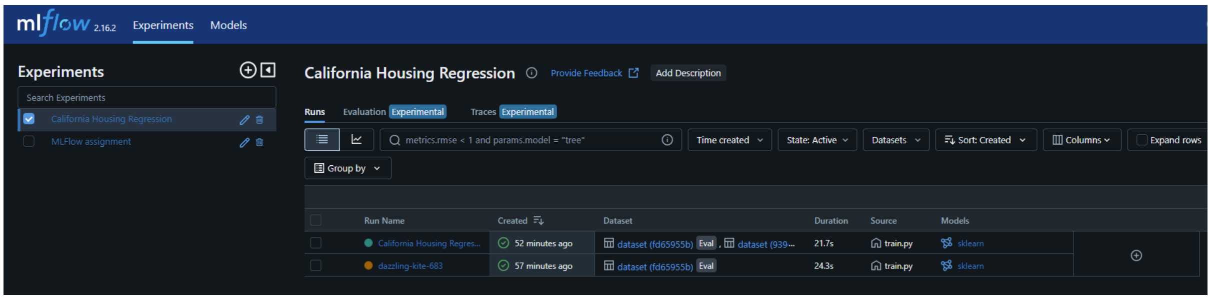
Evaluation Metrics

- **Mean Squared Error (MSE)**: Measures the average squared difference between predicted and actual values. Lower is better.

- **Mean Absolute Error (MAE)**: Measures the average absolute difference between predicted and actual values. Lower is better.
- **R-squared (R^2)**: Explains how well the features explain the variance in the target variable. Higher is better, with 1 being a perfect score.

Results

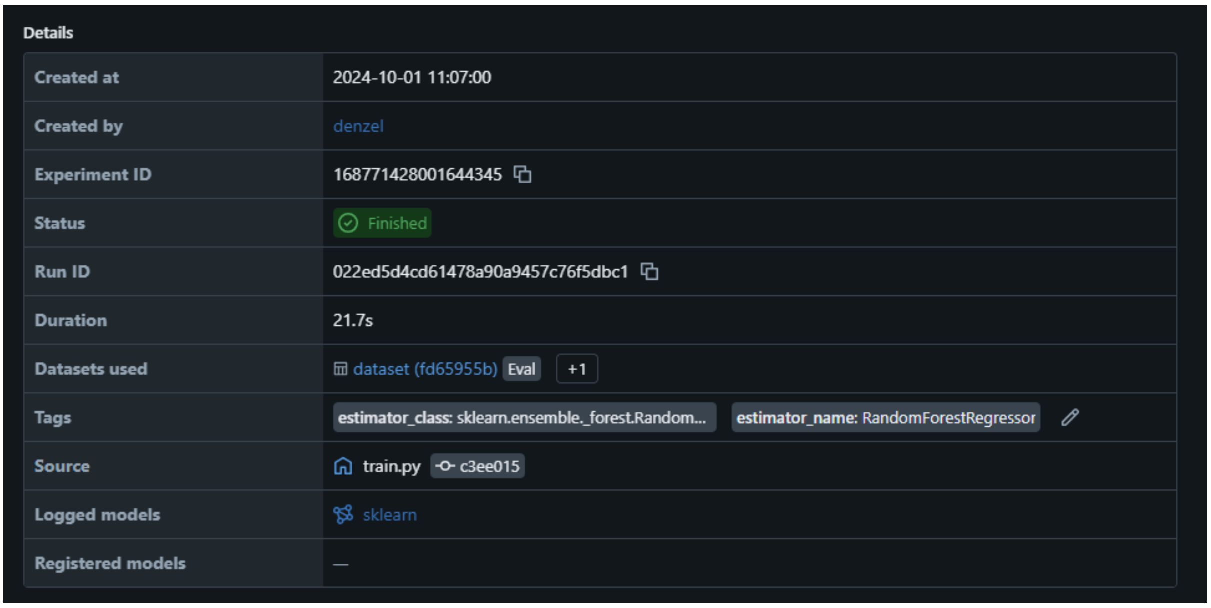
Model	**MSE**	**MAE**	**R^2**
Linear Regression	0.5559	0.5332	0.5758
Random Forest	0.2555	0.3276	0.8050



California Housing Regression

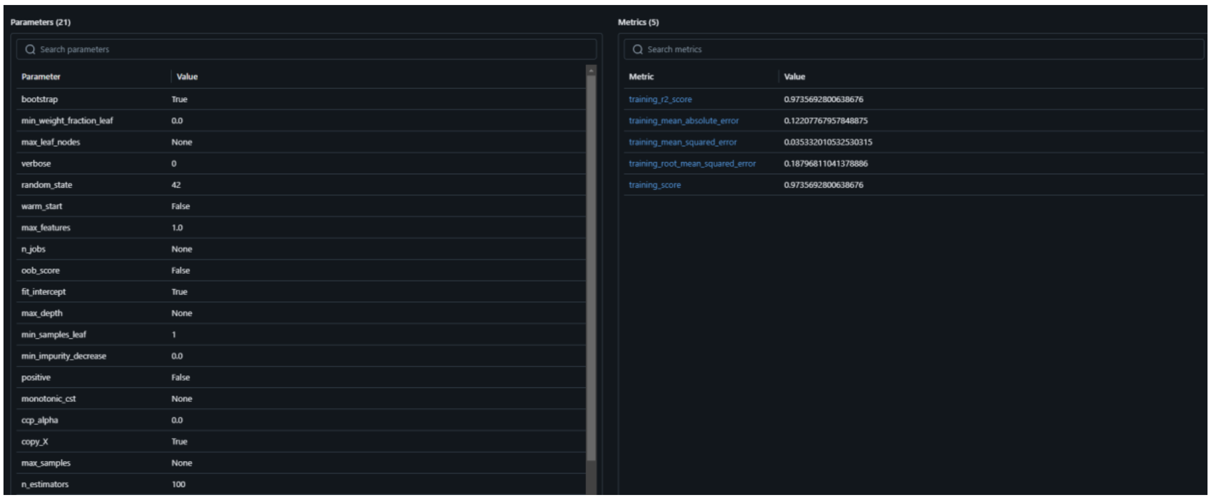
metrics.rmse < 1 and params.model = "tree"

Run Name	Created	Dataset	Duration	Source	Models
California Housing Regres...	52 minutes ago	dataset (fd65955b) Eval , dataset (939...	21.7s	train.py	sklearn
dazzling-kite-683	57 minutes ago	dataset (fd65955b) Eval	24.3s	train.py	sklearn



Details

Created at	2024-10-01 11:07:00
Created by	denzel
Experiment ID	168771428001644345
Status	Finished
Run ID	022ed5d4cd61478a90a9457c76f5dbc1
Duration	21.7s
Datasets used	dataset (fd65955b) Eval +1
Tags	estimator_class: sklearn.ensemble._forest.Random... estimator_name: RandomForestRegressor
Source	train.py c3ee015
Logged models	sklearn
Registered models	—



Parameters (21)

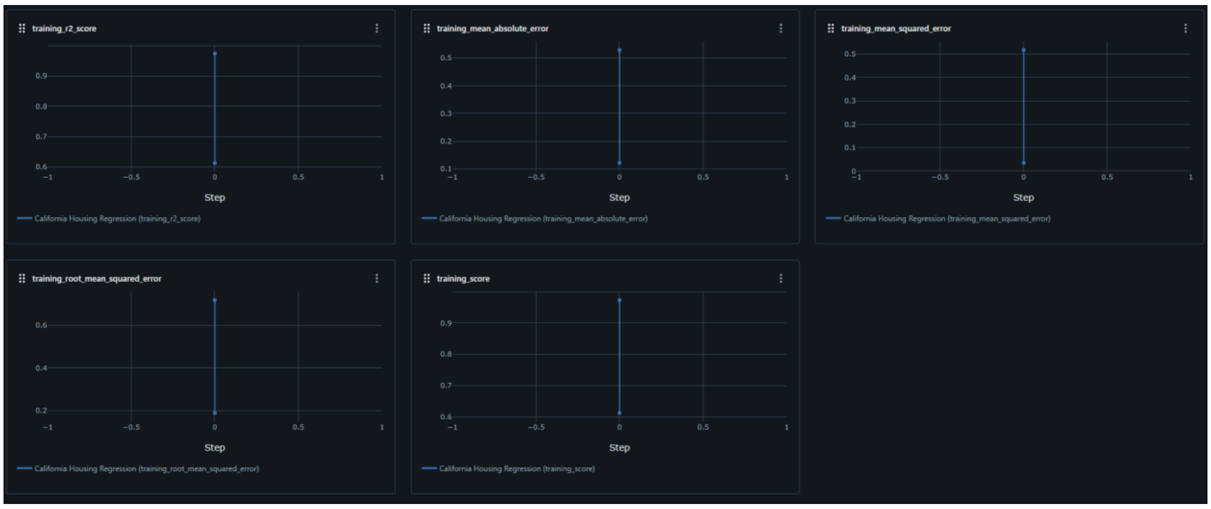
Search parameters

Parameter	Value
bootstrap	True
min_weight_fraction_leaf	0.0
max_leaf_nodes	None
verbose	0
random_state	42
warm_start	False
max_features	1.0
n_jobs	None
oob_score	False
fit_intercept	True
max_depth	None
min_samples_leaf	1
min_impurity_decrease	0.0
positive	False
monotonic_cst	None
ccp_alpha	0.0
copy_X	True
max_samples	None
n_estimators	100

Metrics (5)

Search metrics

Metric	Value
training_r2_score	0.9735692800638676
training_mean_absolute_error	0.12207767957848875
training_mean_squared_error	0.035332010532530315
training_root_mean_squared_error	0.18796811041378886
training_score	0.9735692800638676



Observations:

- **Random Forest** outperforms **Linear Regression** in all evaluation metrics. It has a significantly lower MSE and MAE and a higher R² score, indicating better performance.
- **Linear Regression** shows moderate predictive power but is less robust compared to Random Forest, as indicated by its lower R² score (0.5758) and higher error rates

MLflow Tracking

Each experiment was tracked using MLflow. Key metrics, parameters, and the models were logged, providing insights into the performance of both models over the same dataset.

MLflow Logs:

- **Metrics Tracked**:
  - Mean Squared Error (MSE)
  - Mean Absolute Error (MAE)
  - R² Score
- **Parameters Logged**:
  - Model type (Linear Regression, Random Forest)

  - Hyperparameters (Random Forest hyperparameters such as `n_estimators`, `random_state`)

Model Comparison in MLflow:

MLflow allows for easy comparison of runs, enabling us to visualize and compare the performance of the two models. Random Forest clearly provided better generalization and predictive performance across all metrics.

Conclusion

The Random Forest model performed significantly better than the Linear Regression model, reducing prediction errors and achieving a higher R^2 score. It is recommended to use **Random Forest** for future predictions on this dataset.

Appendix: Code Snippets

```
python
Copy code
# Train Linear Regression
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)

# Train Random Forest Regressor
rf_model = RandomForestRegressor(random_state=42)
rf_model.fit(X_train, y_train)

# Evaluate models
y_pred_lr = lr_model.predict(X_test)
y_pred_rf = rf_model.predict(X_test)

# Log metrics in MLflow
mlflow.log_metric("mse_lr", mean_squared_error(y_test, y_pred_lr))
mlflow.log_metric("mae_lr", mean_absolute_error(y_test, y_pred_lr))
mlflow.log_metric("r2_lr", r2_score(y_test, y_pred_lr))

mlflow.log_metric("mse_rf", mean_squared_error(y_test, y_pred_rf))
mlflow.log_metric("mae_rf", mean_absolute_error(y_test, y_pred_rf))
mlflow.log_metric("r2_rf", r2_score(y_test, y_pred_rf))
```

This report summarizes the model training process and the results logged with MLflow.