Ames House Price Prediction

Kaggle Data Science Project - Advanced Regression

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What is the problem?

- How much are the residential homes in Ames, Iowa given all aspects/attributes of the properties?
- Useful house price prediction for setting data-driven budget for buyers
- Insightful tool for setting more reasonable prices when selling properties
- Build regression models to leverage attributes of properties to predict price

Dataset Description

Ames House Dataset with 79 Attributes and Sale Prices of 1,460 Properties

Feature Examples:

Exterior Features

- Exterior material quality
- Type of foundation
- Masonry veneer type

Interior Features

- Heat condition
- Central air conditioning
- Kitchen quality

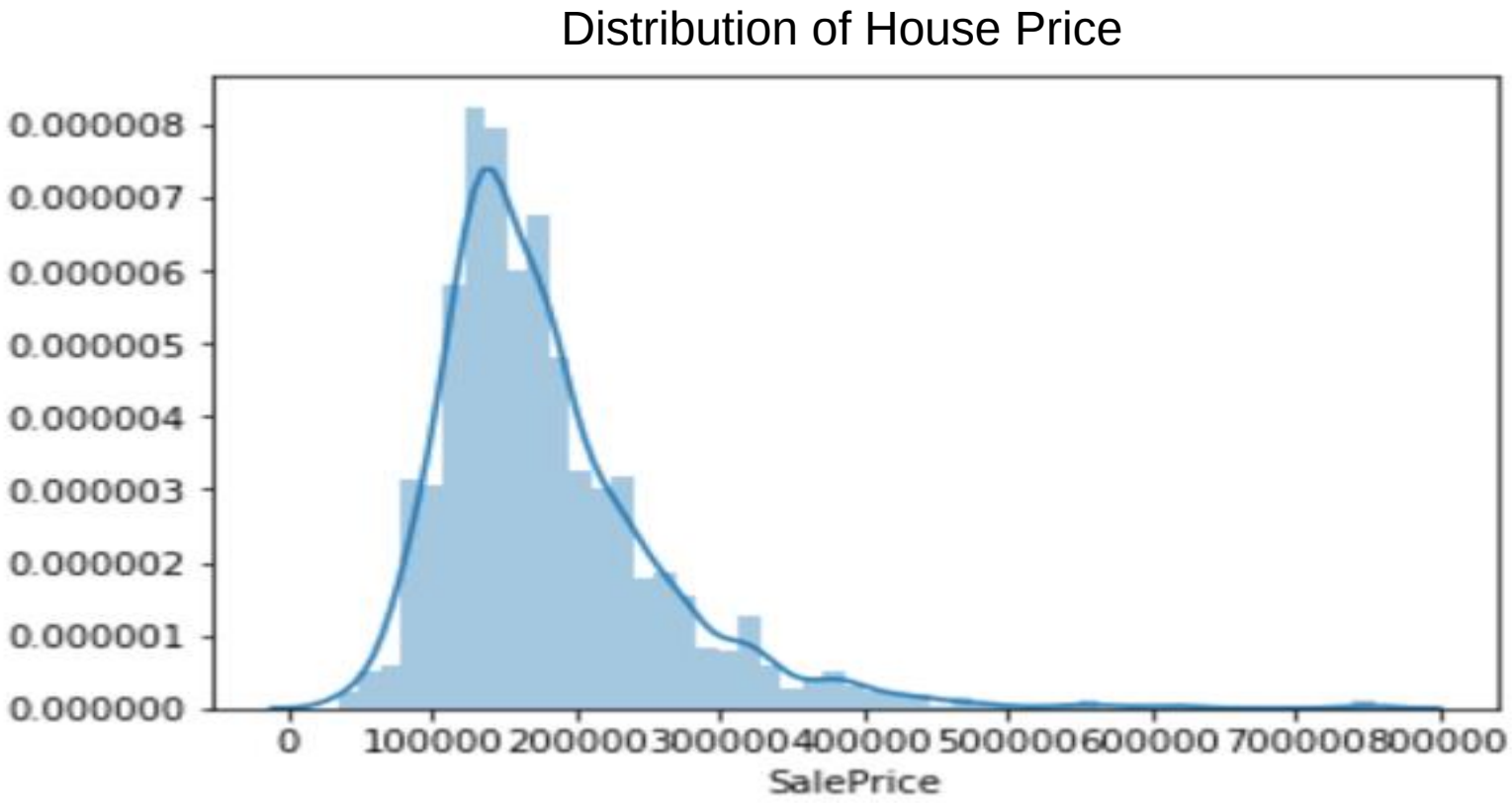
Location Features

- Zoning classification
- Slope of property
- Physical location within city limits

Exploratory Data Analysis

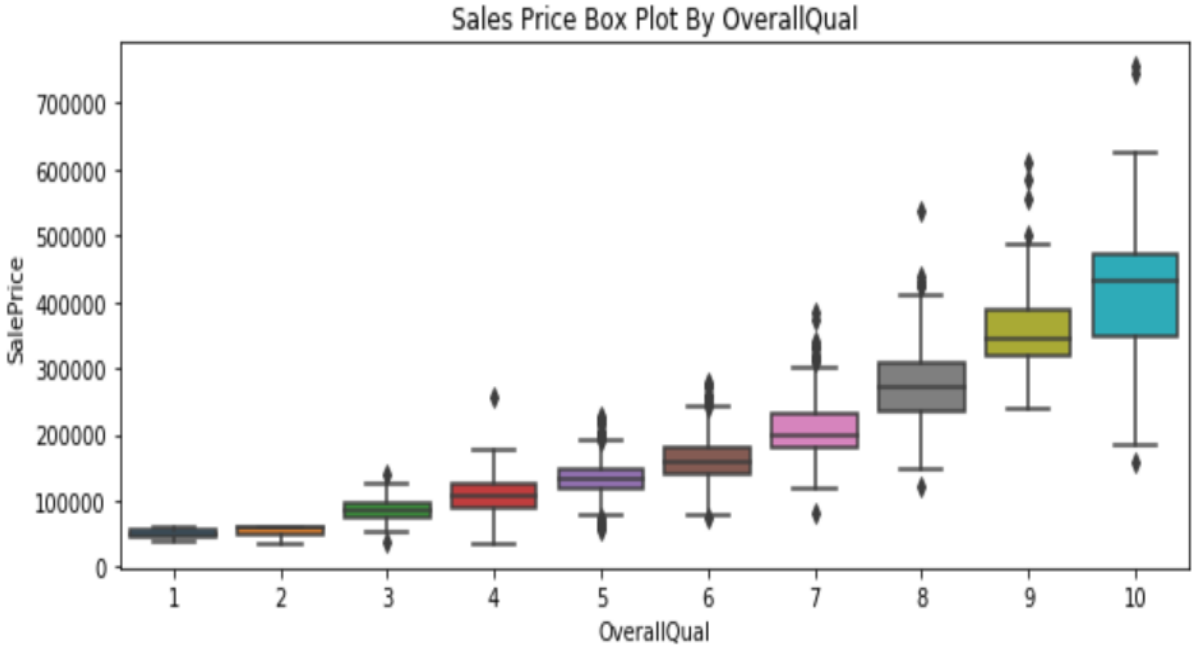
Price of Properties in Ames, IOWA

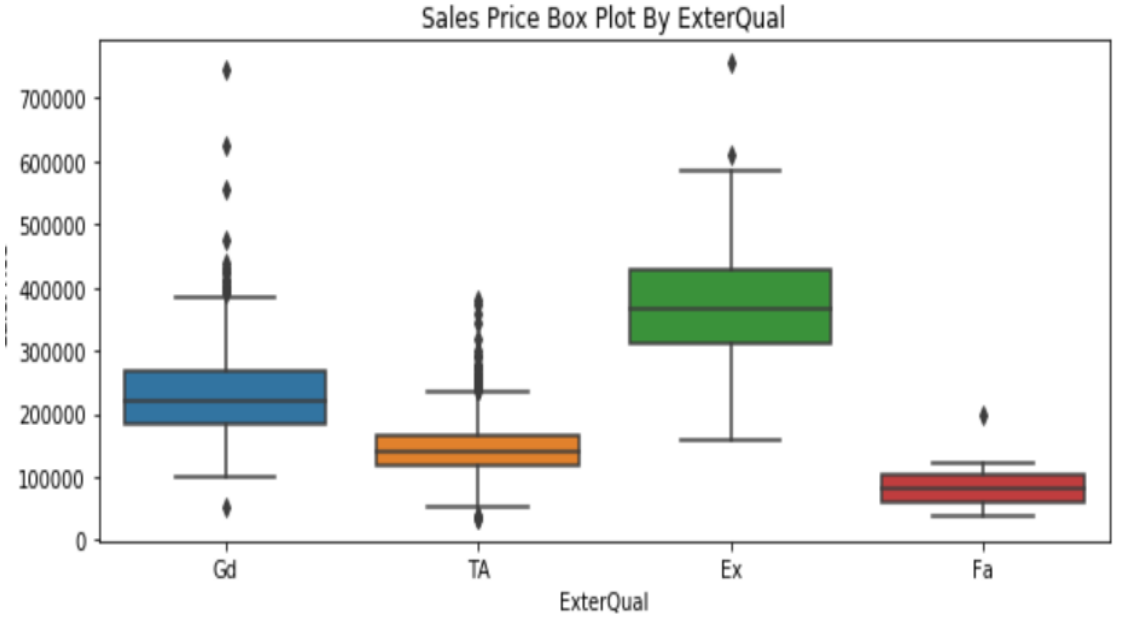
- Average house sale price is around $ 180,000 in Ames.
- There are a few properties over $500,000. But majority of houses are priced under $214,000.



Attributes Most Correlated with Sale Price

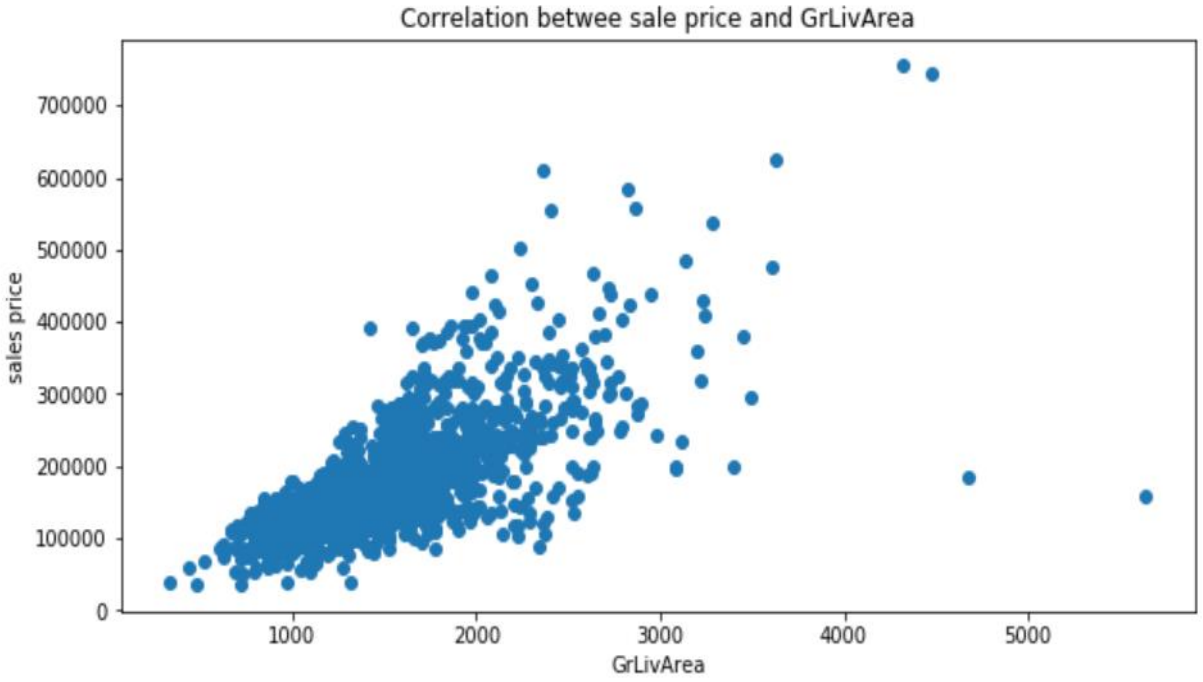
- **Top Significant Categorical Attributes Discovered via ANOVA Test:**
  - **Overall Quality:** The higher the quality score, the higher the sale price.
  - **Exterior Material:** Properties with excellent or good quality tend to be more expensive.
  - **Other significant attributes:** kitchen quality, Height of the basement, Interior finish of the garage, Masonry veneer type, Type of foundation, etc.

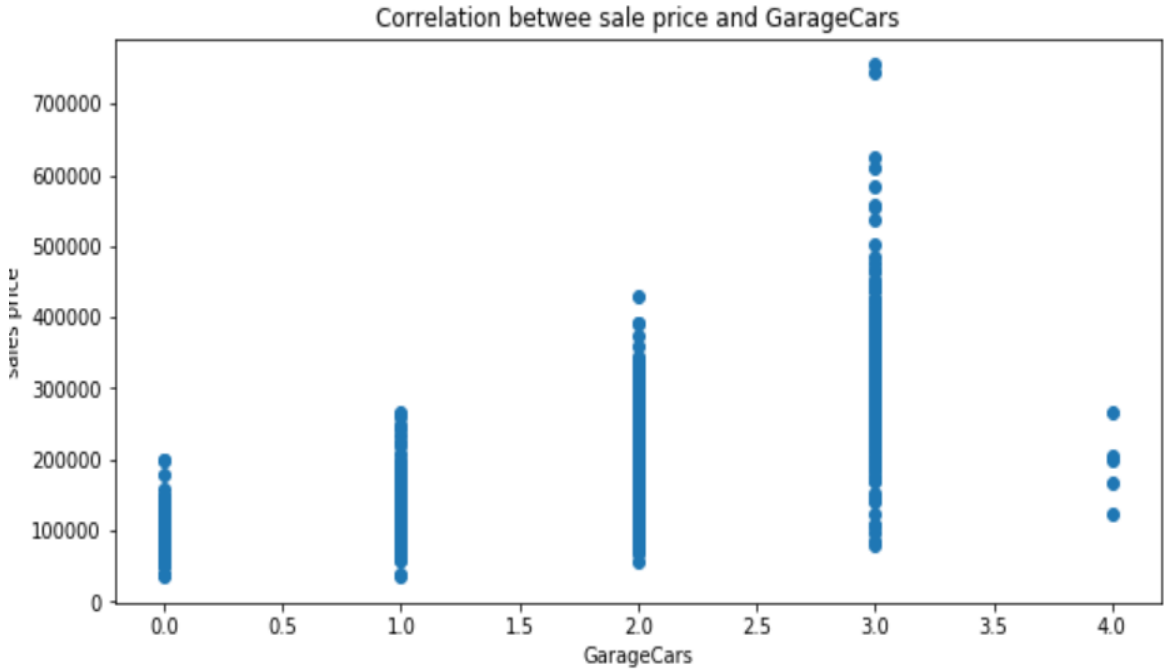




Attributes Most Correlated with Sale Price

- **Top Correlated Attributes Discovered via Correlation Analysis (R Squared & Scatter Plot) :**
  - Above ground living Area in Square Feet
  - Size of Garage in Car Capacity & Square Feet
  - Total Square Feet of Basement Area
  - First Floor Area in Square Feet

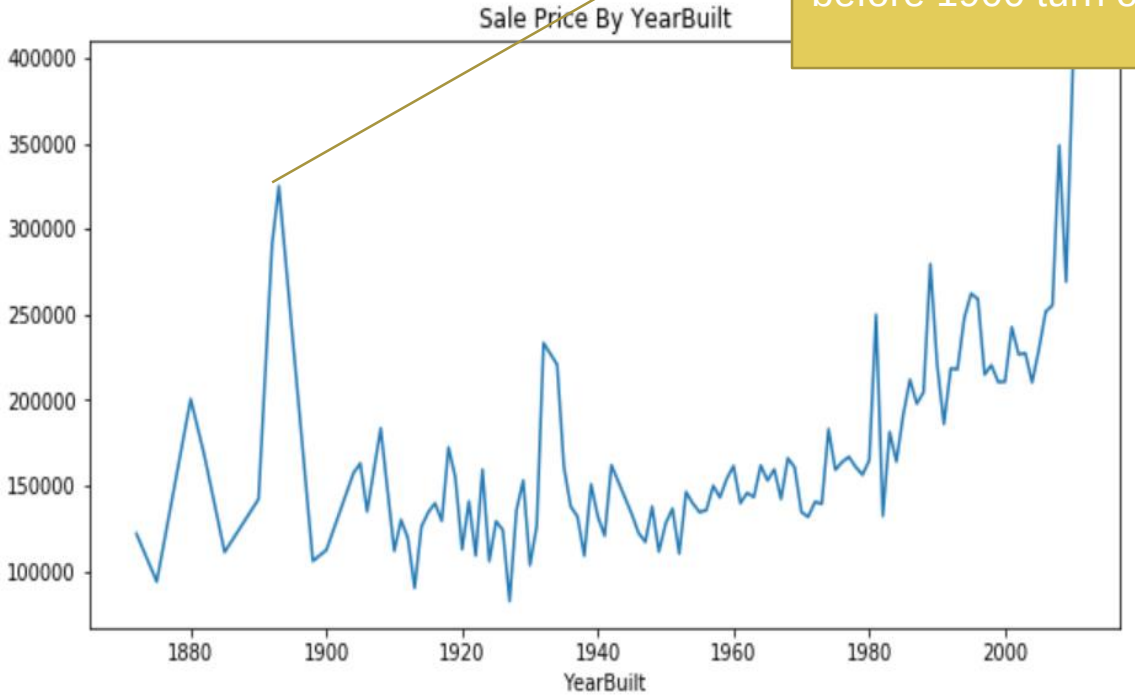




How Timing Impact Property Price

- In general, the more recent the property was built or remodeled, the more expensive it would be.
- The properties sold during second half of the years were more expensive on average than properties sold in the beginning of the years.

Exception case: Properties built right before 1900 turn out to be expensive.



In-Depth Analysis & Modeling

Build Base Regression Models

- **Feature Engineering:**
  - Log Transformation on Skewed Features
  - Standard Scaling on all Features
- **Machine Learning Algorithms Used:**
  - Ridge (L2-Norm)
  - Lasso (L1-Norm)
  - Elastic Net (Combination of L1 & L2 Norm)
  - Gradient Boosting Regressor
  - XG Boosting Regressor
  - Light GBM Regressor
- **Model Optimization:**
  - Randomized Search & Grid Search for Hyperparameter Tuning
  - Optimization Metric: RMSE
- **Model Validation:**
  - Validation Metric: RMSE, MAPE & R Squared

Based on the randomized search 156 is the best alpha to use for the Ridget regression.

```
X_train, X_test, y_train, y_test = func_output_training_testing_datasets(cleaned_transformed_data, test_size=0.25)
random_grid={'alpha': np.linspace(start=1, stop=500, num=30)}
estimator=Ridge()
estimator_name='Ridge'
coefficient_df, intercept, rmse_test, mape_test, R_Squared_test=model_sklearn_model_randomizd_search_fitting_output(random_grid,
X_train, y_train, X_test, y_test, estimator, estimator_name)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed:    5.5s finished

Here's the best parameter from the randomized search: {'alpha': 155.86206896551724}
RMSE on the training set:  0.39393841330416673
RSquared on the training set:  0.8435023666199838


RMSE on the testing set:  0.37291726075507337
RSquared on the testing set:  0.8616394722601429
Mape on the testing set:  0.11415888013607178
```

Randomized Search for Ridge Regression

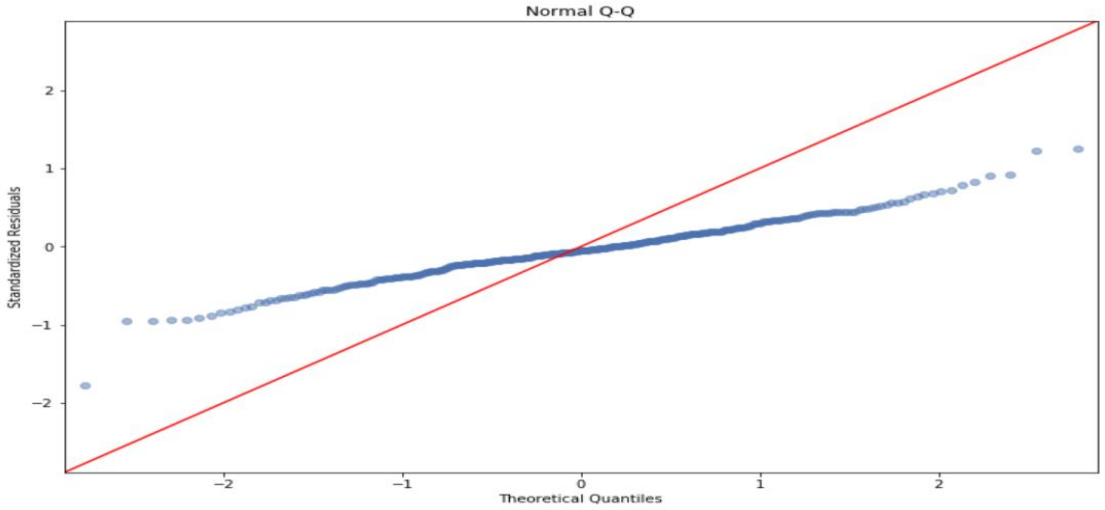
Example Base Model Result
Light GBM Regressor

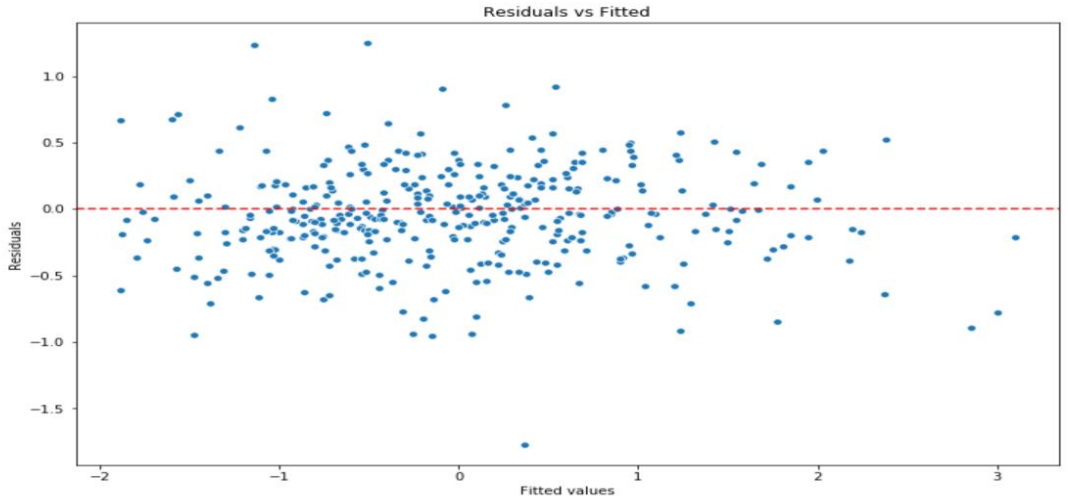
- **Performance on the testing set:**
  - R2: 87%
  - MAPE: 11%
  - RMSE: 0.36
- Predicted sale price is close to the actual price.

Note: RMSE here is calculated based on predicated price and actual price after transformation & scaling.

Example Base Model Result
Light GBM Regressor

- **Residual Analysis:**
  - The model residuals are independently distributed.
  - By looking at the QQ plot, the residuals are not normally distributed.

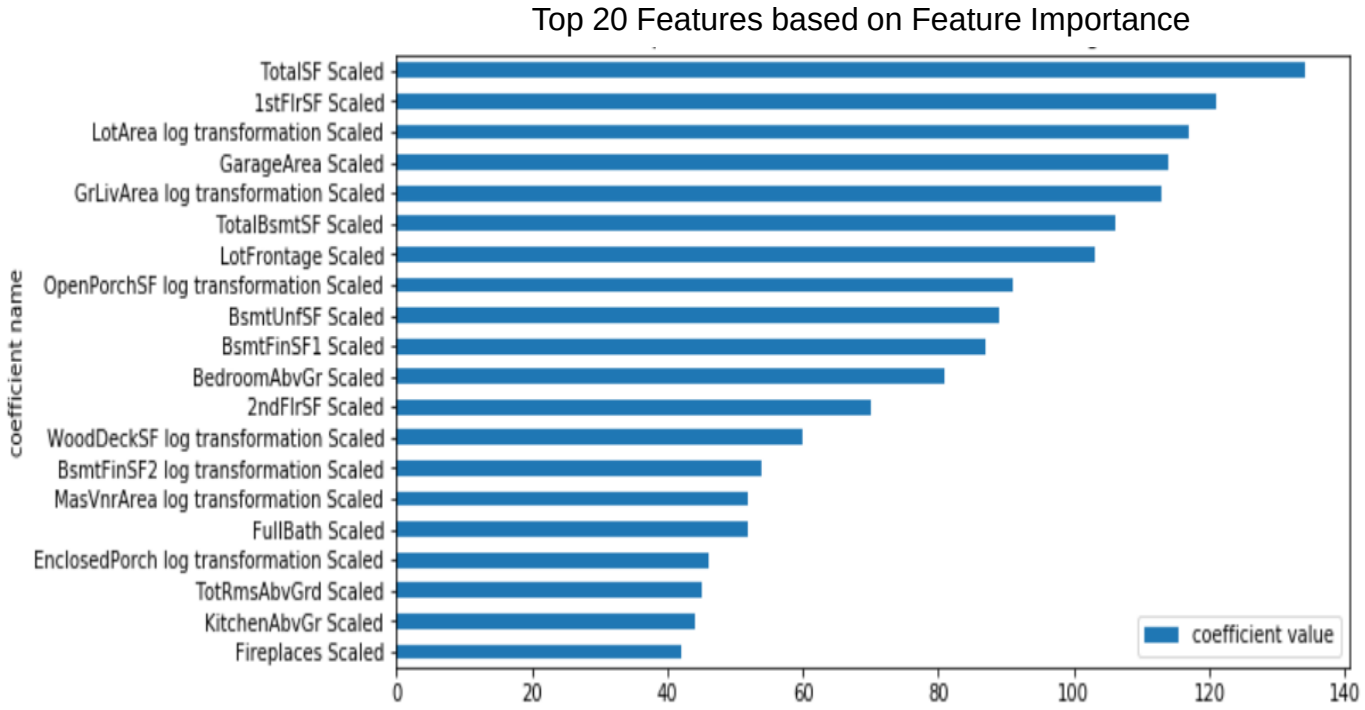




Example Base Model Result

Light GBM Regressor

- **Top 20 features:**
  - All the top 20 features for Light GBM are numerical variables.
  - Most of the features are closely related to the area (in square feet).



Model Accuracy Improvement

- **Pick the most accurate base model:** Light GBM here has the lowest RMSE.
- **Stack all the base models by taking the average of the predictions from the base models:** Stacked model predictions are more accurate than any single base model.

	model name	RMSE	Actual RMSE	Mape
0	Ridge	0.372920	30706.133666	0.431474
1	Lasso	0.375859	30490.569355	0.434702
2	Elastic Net	0.375070	30627.151324	0.433006
3	Gradient Boosting	0.374879	35395.717683	0.432431
4	Xg Boost	0.376148	39531.299038	0.415521
5	Light gbm	0.361896	34834.651064	0.434717

```
Mape before transformation and scalling:  0.42875826657812477
MSE before transformation and scalling:  31285.720650390864
```

Performance of the stacked model

Note: RMSE here is calculated based on predicted price and actual price after transformation & scaling. Actual RMSE is calculated based on predicted price and actual price before transformation & scaling.

Prediction Application

- **Prediction Tool Demo:**
  Use important features as input to output the estimate for sale price.