

Linear Models of Housing Prices in Ames, IA

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Interpretability and Predictive Power

Background & Data Science Problem

- In 2021, the total value of US real estate grew by nearly 19%, to a value of \$43.4 trillion¹
 - Furthermore, a plurality of US citizens believe that investment in real estate is the best way to build personal wealth²
- ❖ A group of real estate investors wants us to build a model to predict sale prices of homes in Ames, IA.
- They care primarily about the predictions being *not too far from correct*
 - They also want to be able to *understand* which features of homes contribute to higher predicted sale prices

1. <https://www.zillow.com/research/us-housing-market-total-value-2021-30615/>

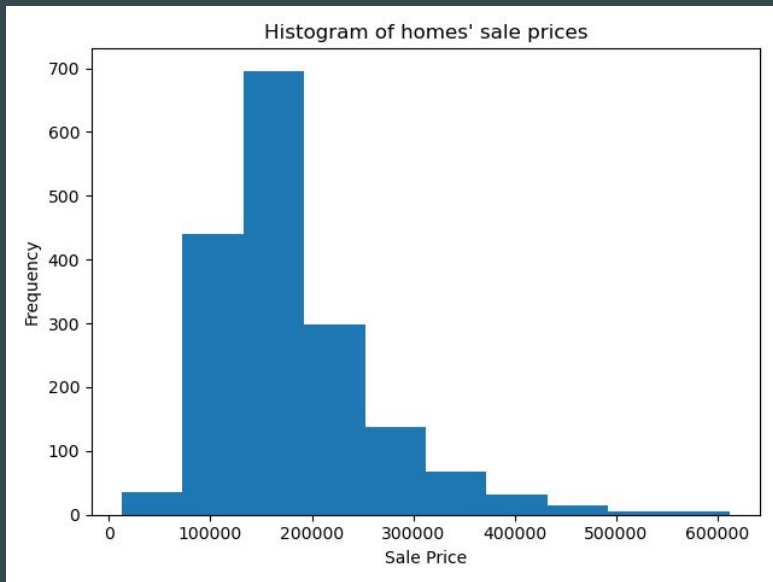
2. <https://www.cnn.com/2022/12/15/americans-say-real-estate-is-best-way-to-build-wealth.html>

Methods

- Data: Ames Housing Dataset
 - Contains data on over 75 features from over 2,000 homes sold in 2006-2010
- Models: Linear regression & regularized linear regression
 - Linear regression: Encode categorical vars with “above-below-mid” (ABM) encoding
 - Regularized regression: Encode categorical vars with dummy vars for each value
- Evaluation:
 - Predictive power: R^2 scores and mean absolute error (MAE) on a reserved set of test data
 - Interpretability: Can we infer effects of features on predicted sale prices?

* <http://jse.amstat.org/v19n3/decock/DataDocumentation.txt>

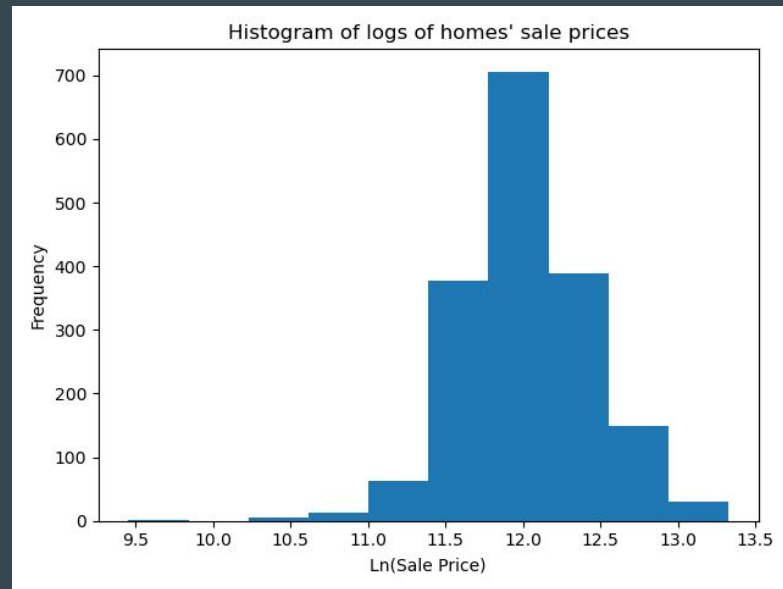
Summary of (Training) Data



Median: \$163,000

Mean: \$181,433

SD: \$79,094

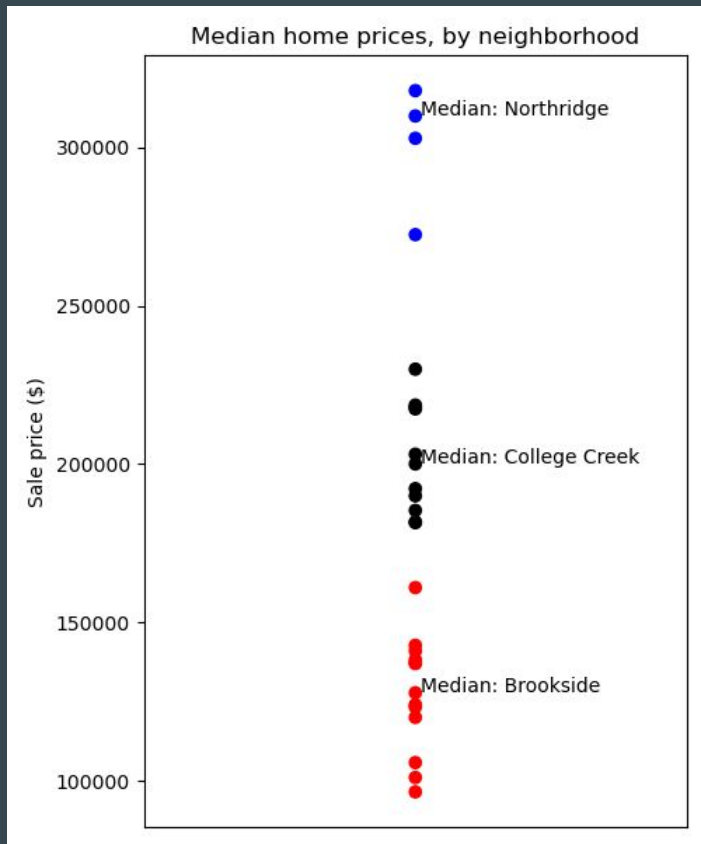


Baselines: Null Model and Optimal Regularized Models

- Null model scores on test data set:
 - R^2 : 0
 - MAE: \$60,525
- Regularized Regressions: LASSO, Ridge, ElasticNet
 - Used gridsearch to find optimal models of each kind
 - No interpretability!
- Best performer: LASSO predicting $\ln(\text{Sale Price})$. Test scores:
 - R^2 : .9286
 - MAE: \$13,464

How to get good predictions while keeping interpretability?

1. Encode categorical variables using above-below-mid (ABM) encoding. For Neighborhood, this looks like:



- 1-unit increase in Neighborhood means:
 - Moving from a “bad” to an “average” neighborhood, OR
 - Moving from an “average” to a “good” neighborhood

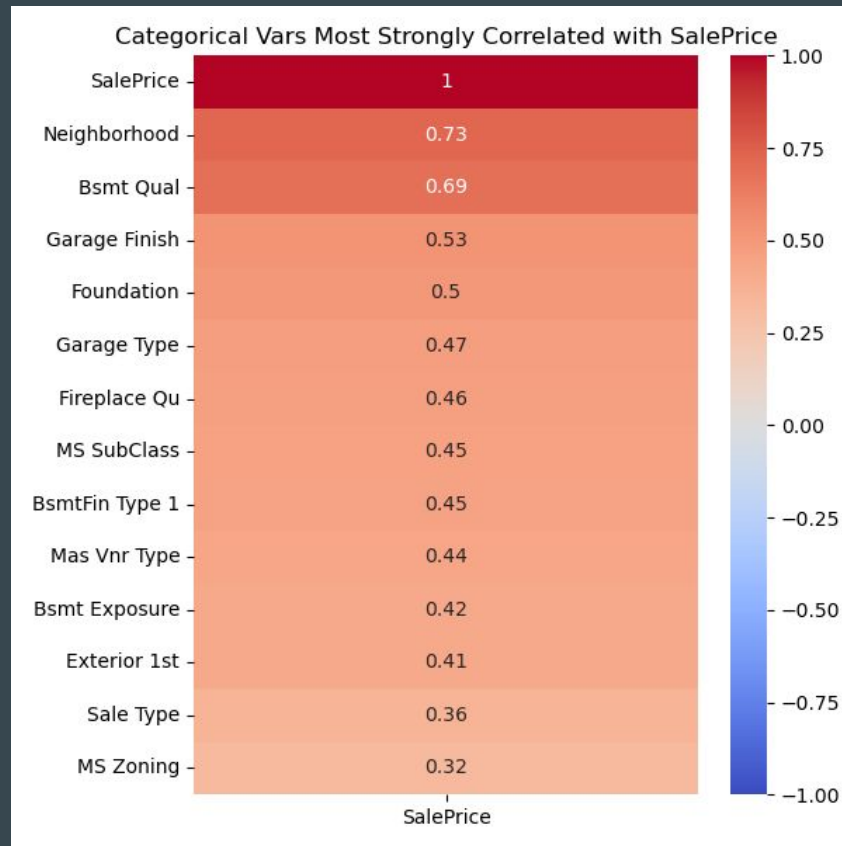
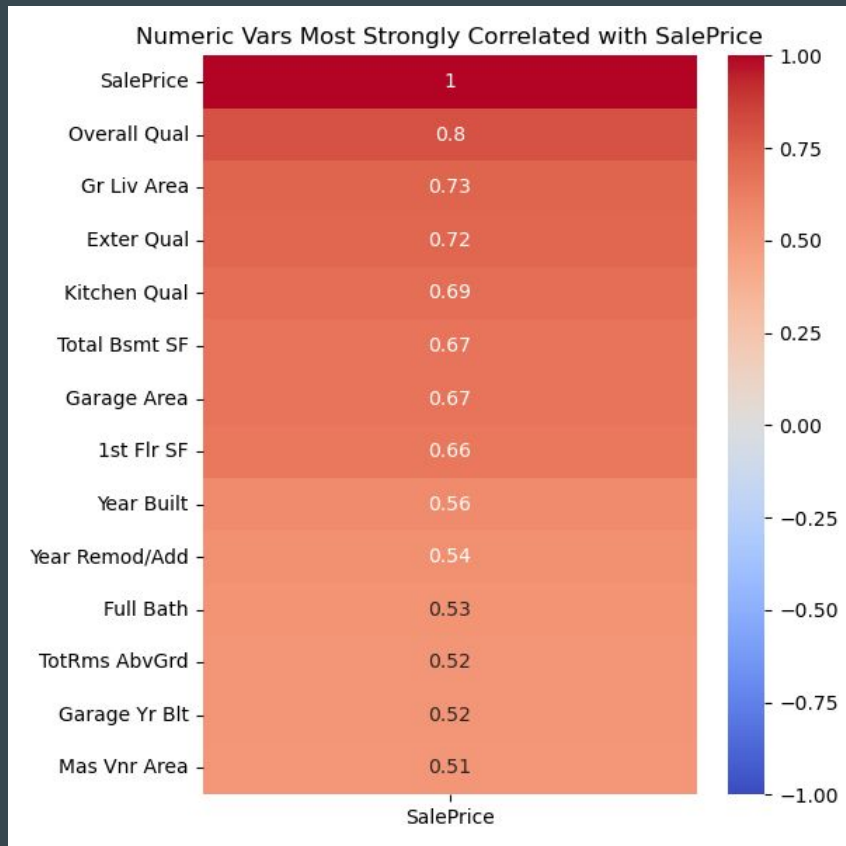
Northridge, Northridge Heights, Stone Brook, Veenker
 (“Good”)

Bloomington Heights, Clear Creek, College Creek,
Crawford, Gilbert, Greens, Green Hills, Northwest Ames,
Sawyer West, Somerset, Timberland
 (“Average”)

Bluestem, Briardale, Brookside, Edwards, Iowa DOT and
Rail Road, Landmark, Meadow Village, Mitchell, North
Ames, Northpark Villa, Old Town, South & West of Iowa
State University, Sawyer
 (“Bad”)

How to get good predictions while keeping interpretability?

2. Add features to a linear model, starting with those most highly correlated with sale price.

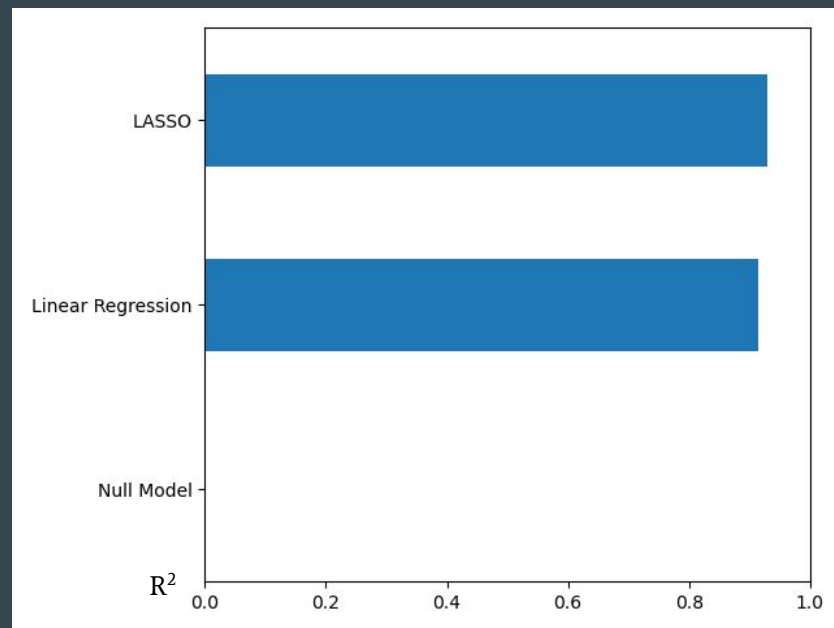
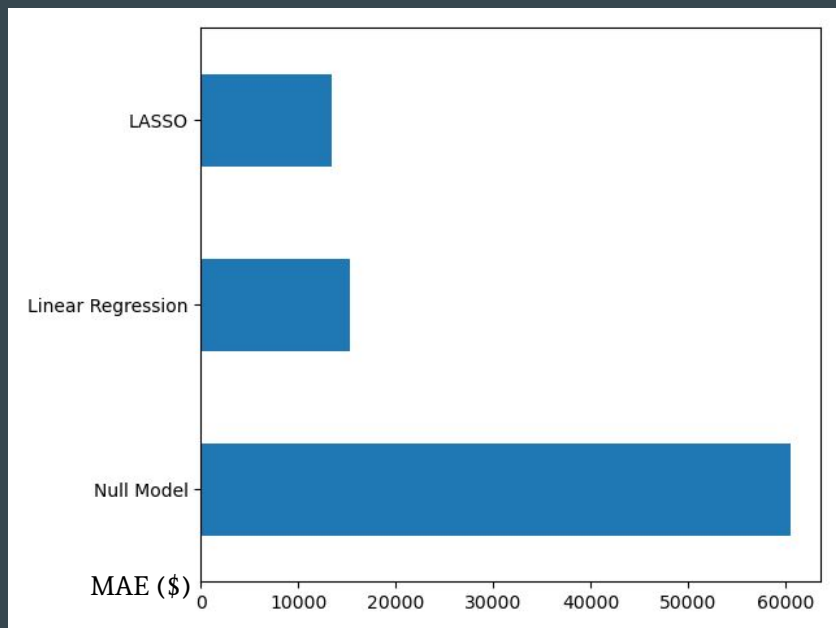


How to get good predictions while keeping interpretability?

3. Try all possibilities and select the model with best predictive power.

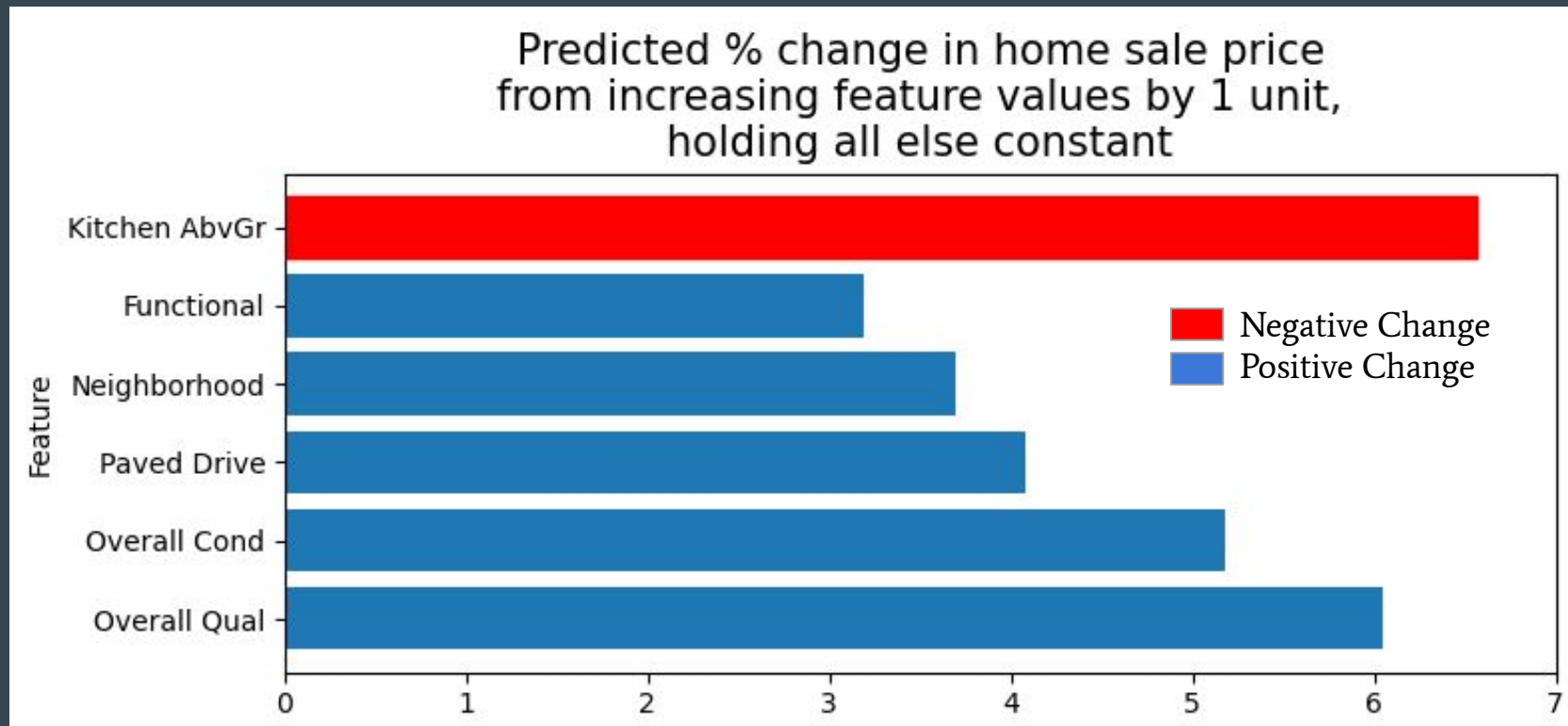
Best linear regression predicting $\ln(\text{Sale Price})$: 32 numeric features, 12 categorical features.

Scores on test data: $R^2 = .915$, $\text{MAE} = \$15,312$



Interpretable model is worse than LASSO by only \$1,848 average prediction error and 1.36% explanatory power

Interpretation of Best Linear Model



Conclusions

- A well-chosen linear regression can have high predictive power while maintaining interpretability
- Gains in predictive power from non-interpretable models may not be worthwhile
- Strongest predictors of higher home sale prices in Ames, IA (all else equal):
 - Quality of materials
 - Condition of home
 - Driveway pavement
 - Neighborhood