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Avoiding the Machine Learning blackbox

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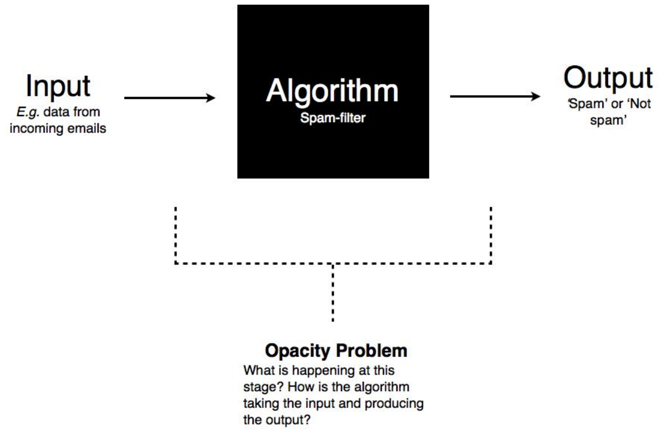
Outline

- Why explain our models
- How we can do it
- Limitations of “feature importance”
- SHAP (with code)
- Plots and explanations
- Next steps

Blackbox algorithms

Device or system of which we only know its inputs and outputs but have no knowledge of its internal workings



Why explain our models

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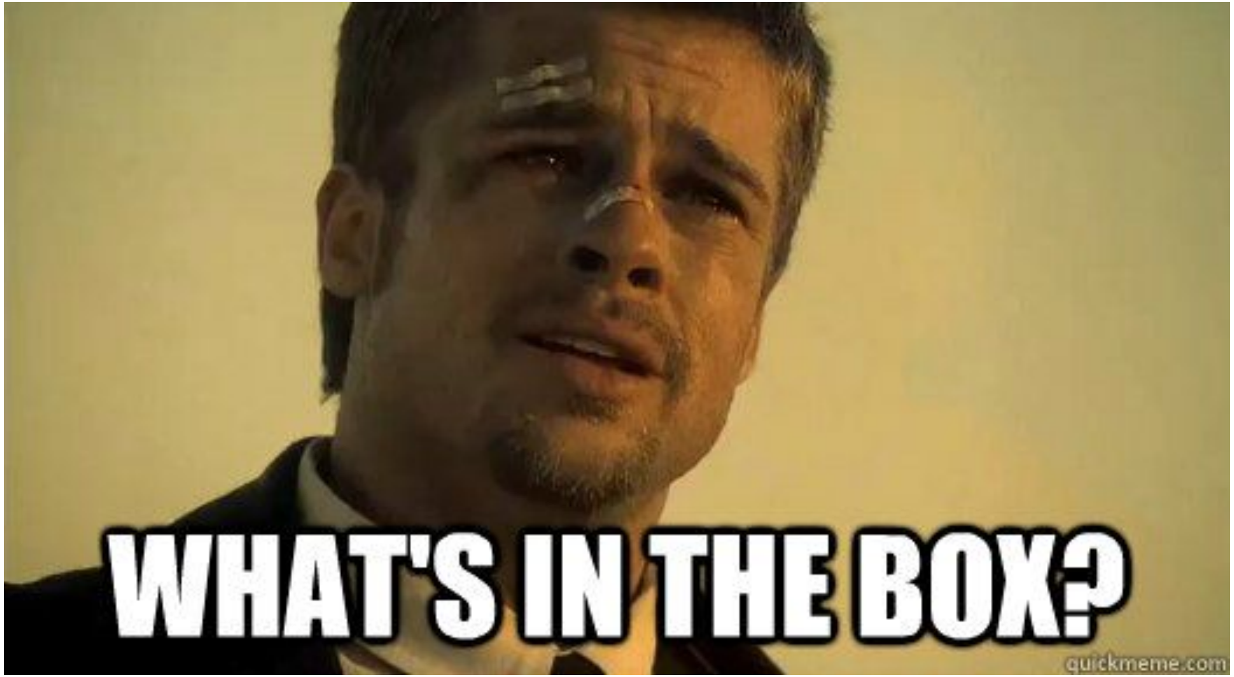
So the question is...



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How we can do it

01	**LIME** *March 2016*	• https://github.com/marcotcr/lime
02	**SHAP** *November 2016*	• https://github.com/slundberg/shap
03	**eli5** *September 2016*	• https://github.com/TeamHG-Memex/eli5
04	**Interpret** *May 2019*	• https://github.com/Microsoft/interpret

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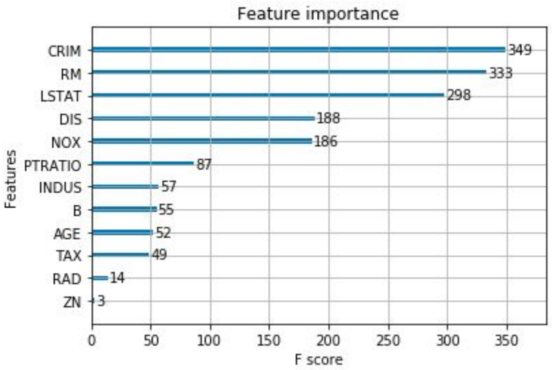
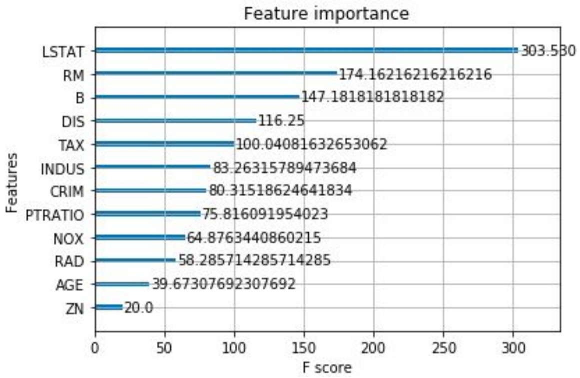
Wait...what about good old "feature importance?"

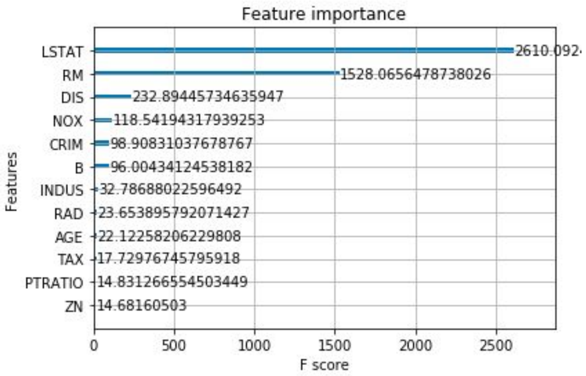
Limitations of “feature importance”



weight

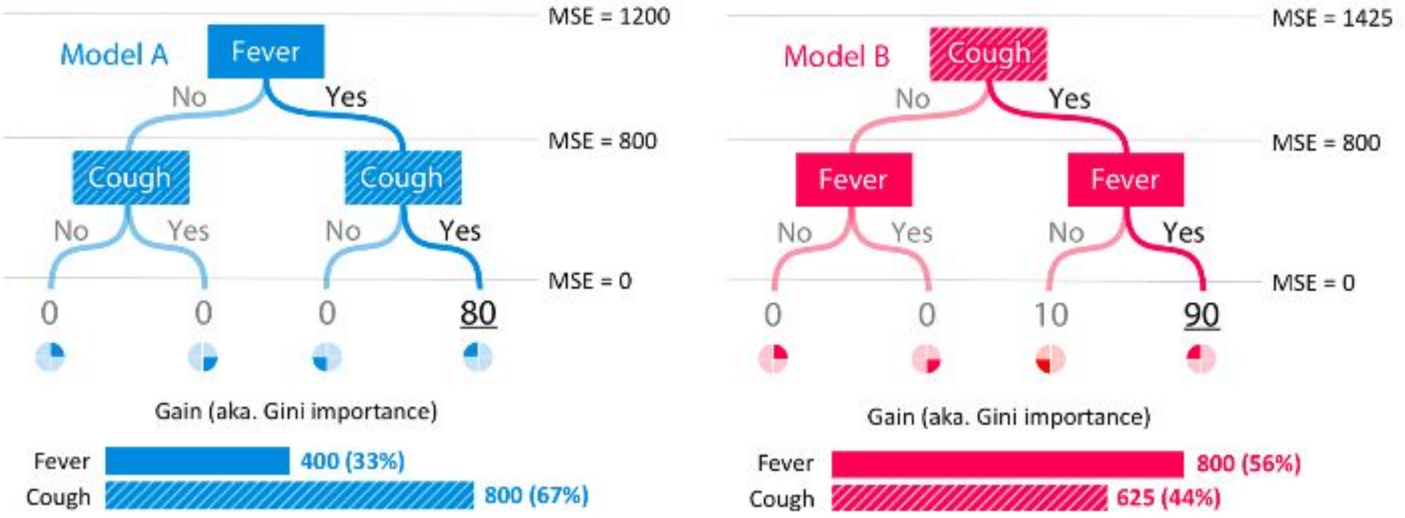


cover



gain

Limitations of “feature importance”



Computation of the gain (aka. Gini importance) scores for model A and model B.

What do we want in an explainer

- Interpretability
- Local fidelity
- Model-agnosticism
- Global perspective

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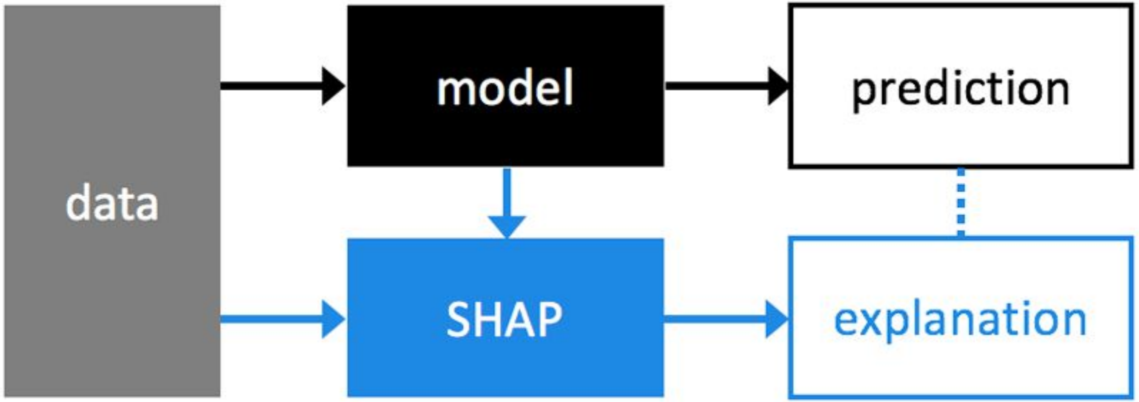
Let's talk about SHAP

About SHAP

- Full name is **SHapley Additive exPlanations**
- Created by Scott Lundeberg (PhD in Univ Washington)
- Paper published at NIPS 2017

How it works (high-level)

- **Method**: Using a less complex model as approximation



http://papers.nips.cc/paper/7062-a-unified-approach-to-interpreting-model-predictions.pdf

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Now let's play a bit

Boston house prices dataset

Information collected by the U.S Census Service concerning houses in the area of Boston

- 13 features
- 1 numeric target
    - Regression task
    - Predict house price

1. CRIM - per capita crime rate by town
2. ZN - proportion of residential land zoned for lots over 25,000 sq.ft.
3. INDUS - proportion of non-retail business acres per town.
4. CHAS - Charles River dummy variable (1 if tract bounds river; 0 otherwise)
5. NOX - nitric oxides concentration (parts per 10 million)
6. RM - average number of rooms per dwelling
7. AGE - proportion of owner-occupied units built prior to 1940
8. DIS - weighted distances to five Boston employment centres
9. RAD - index of accessibility to radial highways
10. TAX - full-value property-tax rate per $10,000
11. PTRATIO - pupil-teacher ratio by town
12. B - 1000(Bk - 0.63)^2 where Bk is the proportion of blacks by town
13. LSTAT - % lower status of the population
14. MEDV - Median value of owner-occupied homes in $1000's

https://www.cs.toronto.edu/~delve/data/boston/bostonDetail.html

Training a model on Boston

Just your *usual suspects*:

- XGBoost
- GridSearch for hyperparameter optimization

Nothing special here!

Run SHAP on trained model

```
# explain the model's predictions using SHAP values
explainer = shap.TreeExplainer(model)
shap_values = explainer.shap_values(X)
```

class **`shap.TreeExplainer`**(*model, data=None, model_output='margin', feature_dependence='tree_path_dependent'*)

Uses Tree SHAP algorithms to explain the output of ensemble tree models.

`shap_values`(*X, y=None, tree_limit=None, approximate=False*)

Estimate the SHAP values for a set of samples.

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SHAP's explanations

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Prediction Explainer

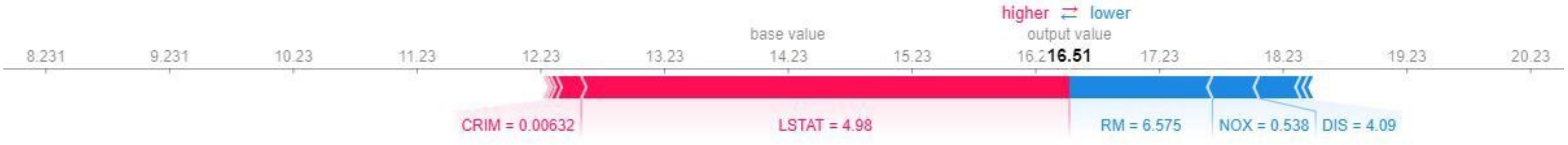
```
# load JS visualization code to notebook
shap.initjs()

# visualize the first prediction's explanation
i = 0
shap.force_plot(explainer.expected_value, shap_values[i,:], X.iloc[i,:])
```

shap.force_plot(*base_value, shap_values, features=None, feature_names=None, out_names=None, link='identity', plot_cmap='RdBu', matplotlib=False, show=True, figsize=(20, 3), ordering_keys=None, ordering_keys_time_format=None, text_rotation=0*)

Visualize the given SHAP values with an additive force layout.

Prediction Explainer



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Model Explainer

```
# load JS visualization code to notebook
shap.initjs()

# visualize the training set predictions
shap.force_plot(explainer.expected_value, shap_values, X)
```

shap.force_plot(*base_value, shap_values, features=None, feature_names=None, out_names=None, link='identity', plot_cmap='RdBu', matplotlib=False, show=True, figsize=(20, 3), ordering_keys=None, ordering_keys_time_format=None, text_rotation=0*)

Visualize the given SHAP values with an additive force layout.

Model Explainer

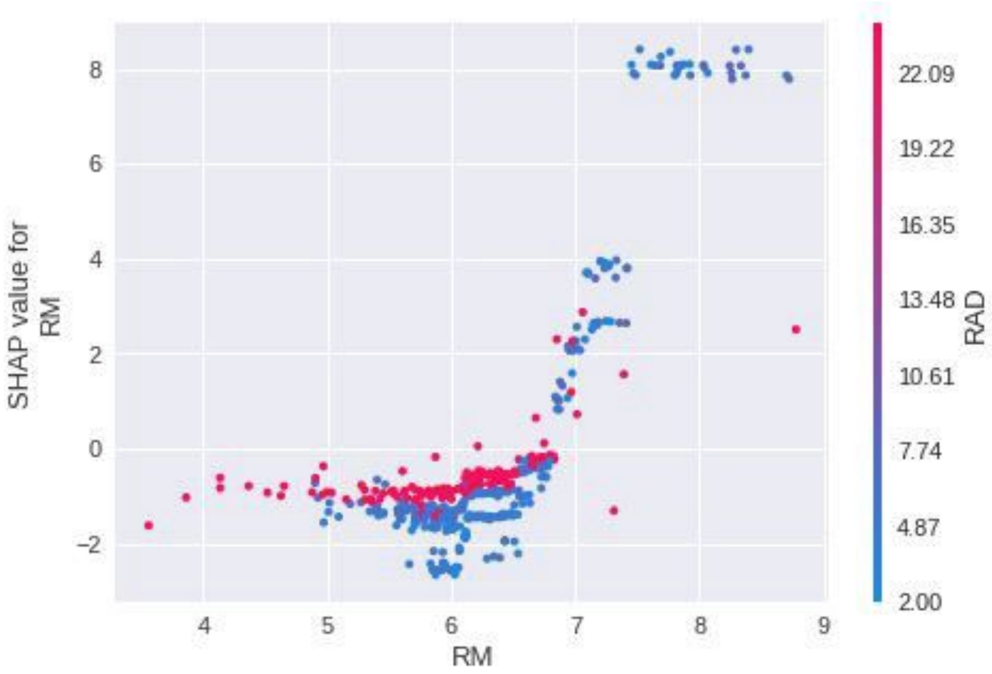
Dependence Plot

```
# load JS visualization code to notebook
shap.initjs()

# create a SHAP dependence plot to show the effect of a single feature across the whole dataset
shap.dependence_plot("RM", shap_values, X, interaction_index="LSTAT")
```

shap.dependence_plot(*ind, shap_values, features, feature_names=None, display_features=None, interaction_index='auto', color='#1E88E5', axis_color='#333333', cmap=<matplotlib.colors.LinearSegmentedColormap object>, dot_size=16, x_jitter=0, alpha=1, title=None, xmin=None, xmax=None, show=True*)

Create a SHAP dependence plot, colored by an interaction feature.

Dependence Plot



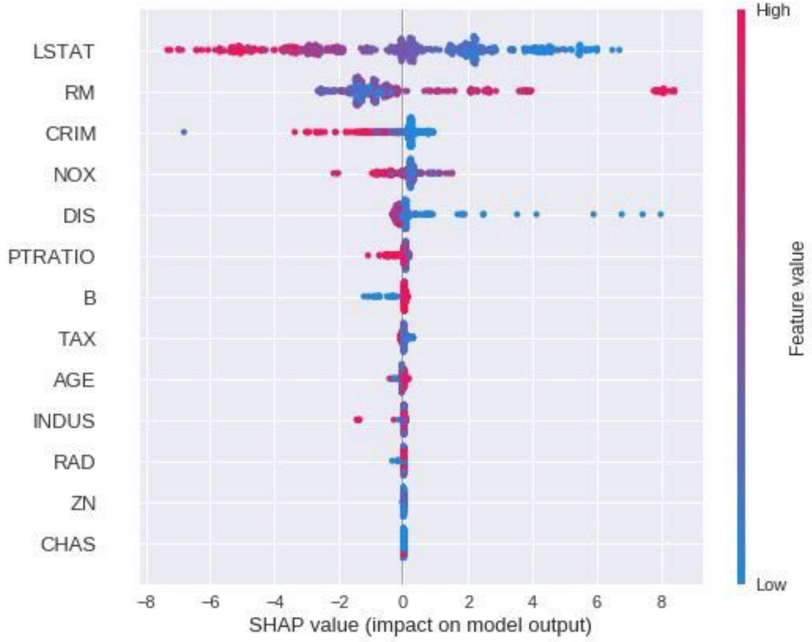
Summary Plot

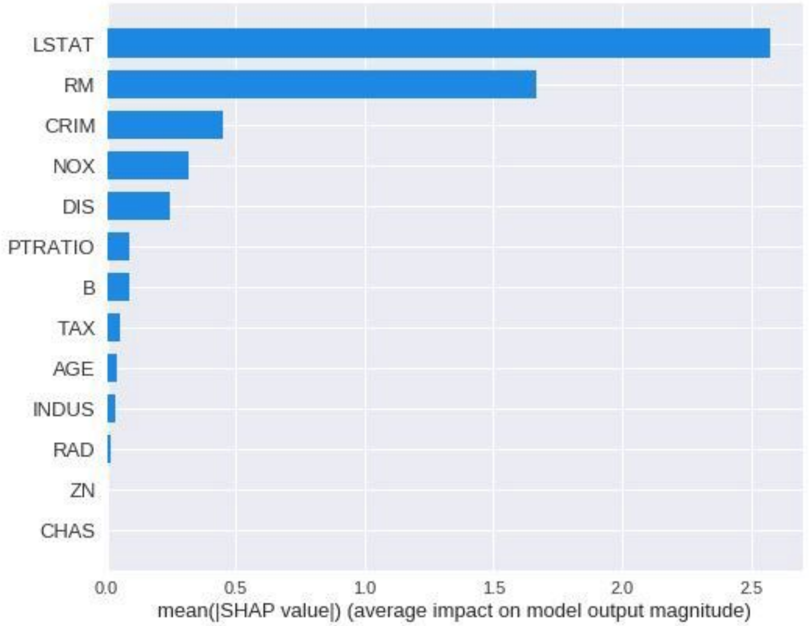
```
# load JS visualization code to notebook
shap.initjs()

# summarize the effects of all the features
shap.summary_plot(shap_values, X)
```

`shap.summary_plot`(*shap_values, features=None, feature_names=None, max_display=None, plot_type='dot', color=None, axis_color='#333333', title=None, alpha=1, show=True, sort=True, color_bar=True, auto_size_plot=True, layered_violin_max_num_bins=20, class_names=None*)

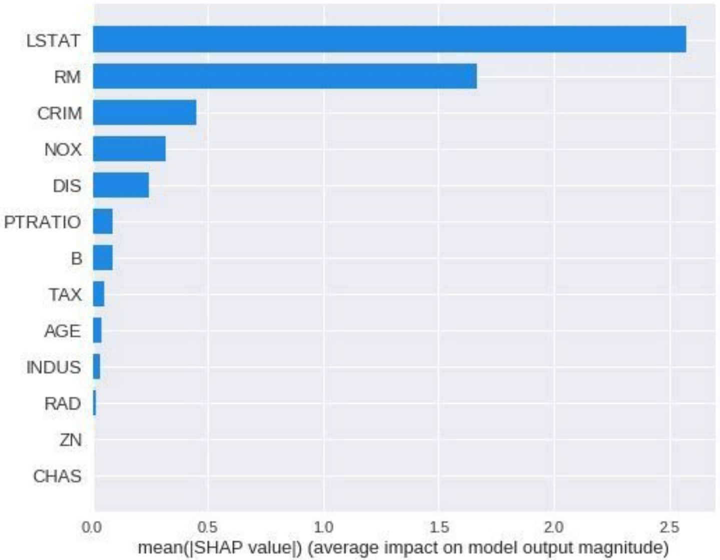
Create a SHAP summary plot, colored by feature values when they are provided.

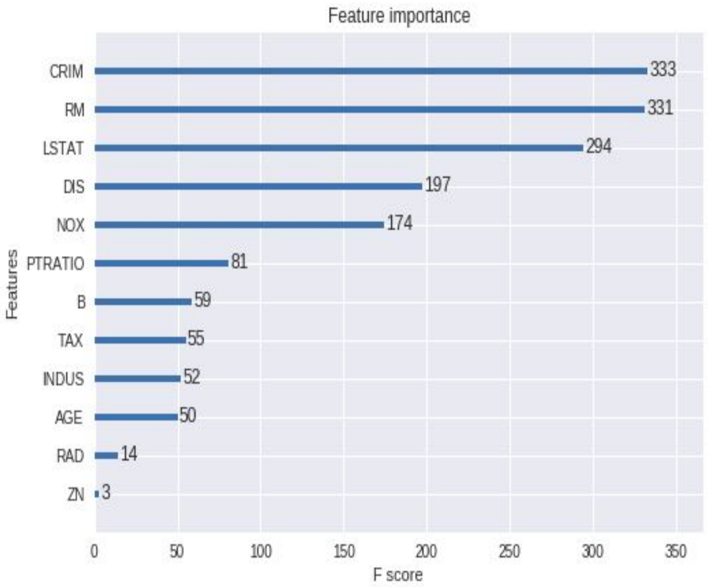
Summary Plot





Compare with "feature importance"





… also, check out "feature permutation"

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Now for some sandbox

Next steps

- **SHAP for classification**: Iris dataset
  - https://archive.ics.uci.edu/ml/datasets/iris
- SHAP official documentation
  - https://shap.readthedocs.io/en/stable/#
- My article on TDS
  - http://bit.do/ml-blackbox-shap
- Scott Lundberg’s article on TDS
  - http://bit.do/lundberg-shap
- Feature importance article
  - https://explained.ai/rf-importance/

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And that's that!

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