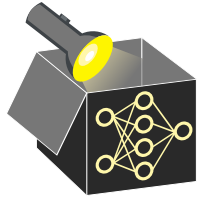
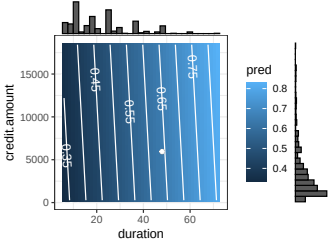
Interpretable Machine Learning



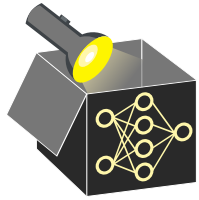
LIME Examples



Learning goals

- See real-world data examples
- See application to image and text data

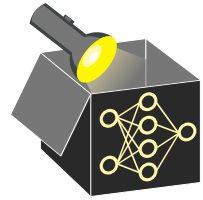
EXAMPLE ON CREDIT DATASET (TABULAR)

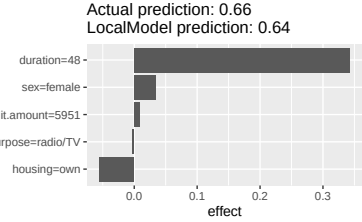


- Model: SVM with RBF kernel
- $\mathbf{x}$: first data point of the dataset with $\hat{f}_{bad}(\mathbf{x}) = 0.658$
- $\mathbf{z}$: training data $\rightsquigarrow$ weighted by the Gower proximity
- Surrogate model $\hat{g}$: L_1-regularized linear model with 5 features

age	sex	job	housing	saving	checking	credit.amount	duration	purpose
22	female	2	own	little	moderate	5951	48	radio/TV

EXAMPLE ON CREDIT DATASET (CONT'D)

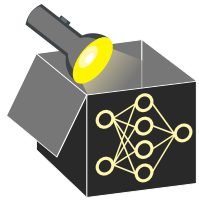




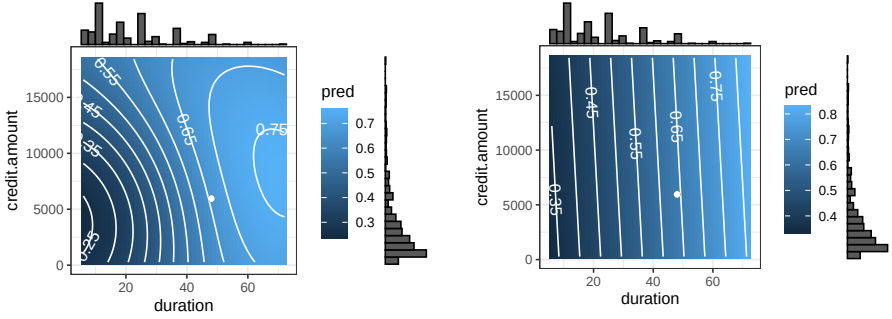
Effects of surrogate model, i.e. $\hat{\theta}^T \mathbf{x}$

- The local model prediction for $\mathbf{x}$ is $\hat{g}(\mathbf{x}) = 0.64$ vs. $\hat{f}(\mathbf{x}) = 0.658$
- $\hat{g}$ has a local fidelity of $L(\hat{f}, \hat{g}, \phi_{\mathbf{x}}) = 4.82$ with $\phi_{\mathbf{x}}(\mathbf{z})$ as the Gower proximity and $L(\hat{f}_{bad}(\mathbf{z}), g(\mathbf{z}))$ as the euclidean distance

EXAMPLE ON CREDIT DATASET (CONT'D)



- 2-dim ICE plots (aka. prediction surface plot) of credit amount and duration show how the surrogate model g linearly approximates the previously nonlinear prediction surface of $\hat{f}_{bad}$

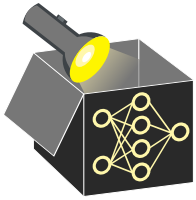


2-dim ICE plot of $\hat{f}_{bad}$ (**left**) and surrogate g (**right**) for features duration and credit amount.

The white dot is **x**. The histograms display the marginal distribution of the training data **X**.

LIME FOR TEXT DATA

▸ Shen, Ian, (2019)



LIME can also be applied to text data:

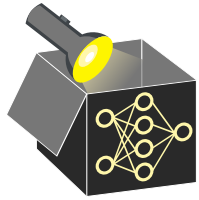
- Raw text representations:
  - Binary vector indicating the presence or absence of a word
  - A vector of word counts
- Examples for *“This text is the first text."* and *“Finally, this is the last one."*:

this	text	is	the	first	finally	last	one
1	2	1	1	1	0	0	0
1	0	1	1	0	1	1	1

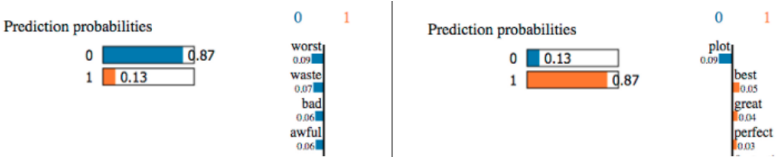
- **Sampling**: Randomly set the entry of individual words to 0; equal to removing all occurrences of this word in the text.
- **Proximity**: Exponential kernel with cosine distance.
  - Neglects words that do not occur in both texts
  - Measures the distance irrespective of the text size

LIME FOR TEXT DATA (CONT'D)

▸ Shen, Ian, (2019)

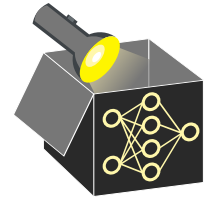


- Random forest classifier labeling movie reviews from IMDB
  - 0: negative
  - 1: positive
- Surrogate model is a sparse linear model



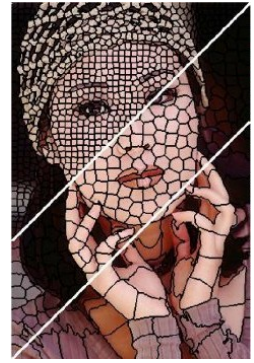
Words like "worst" or "waste" indicate negative review while words like "best" or "great" indicate positive review

LIME FOR IMAGE DATA



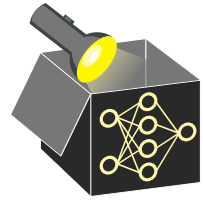
LIME also works for image data:

- **Idea**: Each obs. is represented by a binary vector indicating the presence or absence of superpixels
  ▸ Achanta et al. 2012
- Superpixels are interconnected pixels with similar colors (absence of a single pixel might not have a (strong) effect on the prediction)
- **Warning**: Size of superpixels needs to be determined before the segmentation takes place
- **Sampling**: Randomly switching some of the super pixels “off", i.e., by coloring some superpixels uniformly

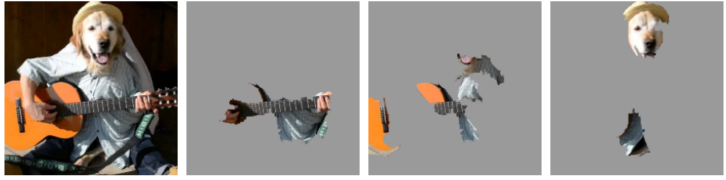


Example for superpixels of different sizes

LIME FOR IMAGE DATA (CONT'D) ▸ Ribeiro. 2016



- Explaining prediction of pre-trained inception neural network classifier
- **Sampling**: Graying out all superpixels besides 10 superpixels
- **Surrogate**: Locally weighted sparse linear models
- **Proximity**: Exponential kernel with euclidean distance



(a) Original Image (b) Explaining *Electric guitar* (c) Explaining *Acoustic guitar* (d) Explaining *Labrador*

Top 3 classes predicted