Visualizations For Justifying Machine Learning Predictions

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Motivation

• Strengths of ML allowed expansion to diverse fields
• Fields and contexts far removed from traditional ML
• Users not trained in ML
  • Eg. Medical field: Doctors use ML to predict disease given symptoms
  • The ML is a black box to them: Input $\rightarrow ? \rightarrow$ Output

\[
\text{maximize } f(c_1, \ldots, c_n) = \sum_{i=1}^{n} c_i - \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} y_i c_i (\varphi(\tilde{x}_i) \cdot \varphi(\tilde{x}_j)) y_j c_j \\
= \sum_{i=1}^{n} c_i - \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} y_i c_i k(\tilde{x}_i, \tilde{x}_j) y_j c_j \\
\text{subject to } \sum_{i=1}^{n} c_i y_i = 0, \text{ and } 0 \leq c_i \leq \frac{1}{2n\lambda} \text{ for all } i.
\]
Previous Work

The prediction, given by Linear Regression, is $Y$

The most important evidence for the prediction is in SLOPE and Y_PRIOR. This is normal, as these features are often important for predictions of this class.

Normally, we would see powerful counter-evidence in DIAMETER, but it is missing in this case.

Significant counter-evidence exists in VENUE. This is exceptional, as it is not usually a strong feature.

Key feature list:
- SLOPE (Normal evidence)
- Y_PRIOR (Normal evidence)
- DIAMETER (Missing counter-evidence)
- VENUE (Exceptional counter-evidence)

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Some issues:

- The vis relies on NLG quite a bit
- Vis isn’t very clear for non-experts (what is Y-Prior? What is Slope?)

Goals

• Justify a ML prediction to a non-expert user
• Show features providing evidence for/against the prediction
• Select and visualize key features
• Focus on interpretable models
• Simplicity not complexity...

Figure: Munzner, T. (2014). Visualization Analysis and Design. CRC Press.
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Feature Visualizing

Vis can show effect and importance\(^1\)

- **Effect**: extent to which a feature contributes toward or against prediction
  \[
  \text{Effect}_{ji} = \theta_{ji}x_i
  \]

- **Importance**: Expected effect of the feature for a particular class (mean feature value for the class)
  \[
  \text{Importance}_{ji} = \theta_{ji} \frac{\sum_{x \in X^j} x_i}{|X^j|}
  \]

Abstraction

• Some raw data: arbitrary data with training/test sets
• Task abstraction:
  - Analyze: discover, enjoy, derive
• Data abstraction:
  - Items, attributes, values in a table
• Two quantitative variables: effect, importance -- scatterplot effective
Demo
Future Direction

NLG implemented

Full web app implementation

Expanded scope:
Thanks!

Questions?
The prediction is **Against** Survived.

The effect of a feature is the amount it contributes for or against a positive prediction. The importance of a feature is the expected effect of a feature.

Clicking the Key Features button in the scatterplot displays a highlighted area in which any overlapping points on the graph are both high effect and high importance. Key Features are those that contribute strongly either to or against a prediction as expected.

Sex is a key feature with a high effect and high importance. Age is a key feature with a high effect and high importance. Embarked_C is a key feature with a high effect and high importance.

The features that contribute strongly to this prediction are Sex and Age.