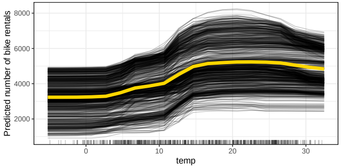
Interpretable Machine Learning

Feature Effects

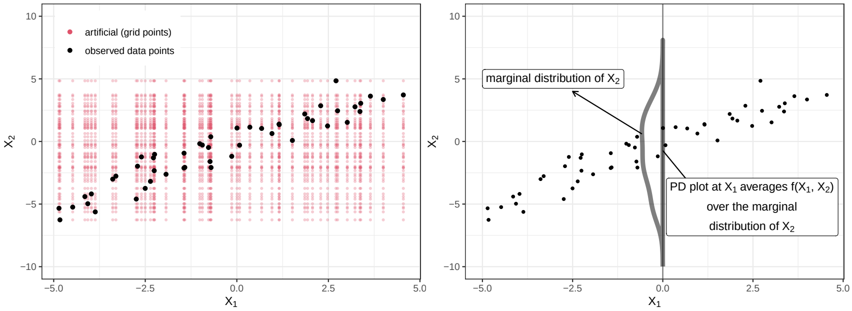
PDP - Comments and Extensions



Learning goals

- Extrapolation and Interactions in PDPs
- Centered ICE and PDP

COMMENTS ON EXTRAPOLATION



Extrapolation occurs in regions with few obs. or if features are correlated

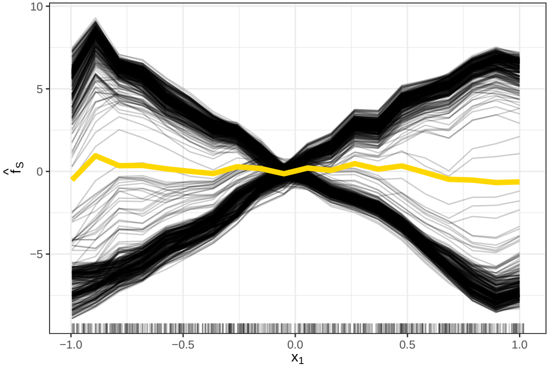
- **Example:** Features x_1 and x_2 are strongly correlated
- **Black points:** Observed points of the original data
- **Red:** Grid points to calculate ICE/PD (many unrealistic x_1, x_2 combinations)
  $\Rightarrow$ **PD at $x_1 = 0$:** Averages predictions over *full* marginal distribution of x_2
  $\Rightarrow$ **Issue:** Model may behave strangely outside training distribution
  $\Rightarrow$ Especially problematic for overfitted or interaction-heavy models

COMMENTS ON INTERACTIONS

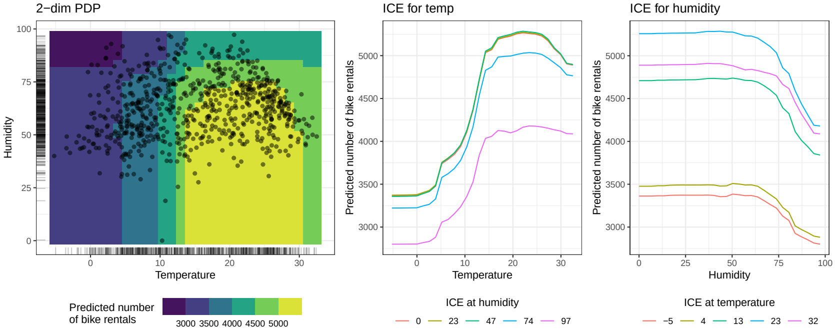
PD plots average ICE curves

⇝ May **obscure heterogeneous effects** (interactions)

- **Example:** Feature x_1 = treatment dosage; x_2 = gender
  $\Rightarrow$ Males (↗) and females (↘) respond differently to dosage
  $\Rightarrow$ PD curve (yellow) hides this divergence
- Plotting ICE and PD together helps detect interaction
- Diverse ICE shapes suggest interaction (but not with which feature)



COMMENTS ON INTERACTIONS - 2D PD PLOT



- Humidity and temperature interact at high values (see shape difference)

  ⇝ ICE curve shape changes across different (higher) values of other feat.
  - ICE (temp): At high humidity, temp effect flattens (pink line)
  - ICE (hum): At high temp., humidity effect falls steeper (blue/pink)
- Most rentals occur at *high temperature* and *low to medium humidity*

CENTERED ICE PLOT (C-ICE) ▸ GOLDSTEIN_2015

Issue: Varying-intercept (stacked) ICE curves obscure shape heterogeneity
Solution: Center ICE curves at fixed reference value, often $x' = \min(_S)$
⇒ Easier to identify heterogeneous shapes with c-ICE curves

$$^{(i)}_{S,cICE}(s) = (s, \xi_{-S}) - (x', \xi_{-S}) =^{(i)}_{S} (s) -^{(i)}_{S} (x')$$

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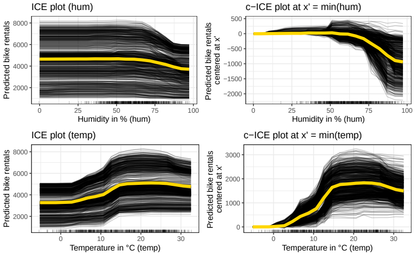
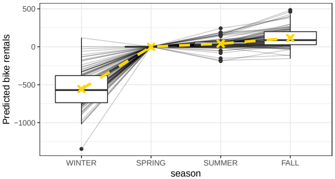
Interpretation

- Yellow: c-PDP (mean of c-ICE)
- **c-PDP:** At 97% humidity, predicted rentals are 1000 fewer than at 0% humidity (on average)
- **Opening of c-ICE curves:** suggests interaction or varying effect across instances



CENTERED ICE PLOT (C-ICE)

Categorical features: c-ICE plots can be interpreted as in LMs due to reference value



Interpretation:

- The reference category is $x' =$ SPRING
- Yellow crosses: Average rentals if we jump from SPRING to any other season $\Rightarrow$ Number of bike rentals drops by $\sim$ 560 in `WINTER` and is slightly higher in `SUMMER` and `FALL` compared to `SPRING`