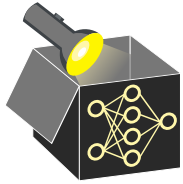
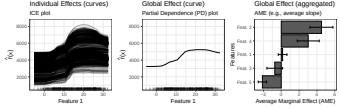
Interpretable Machine Learning



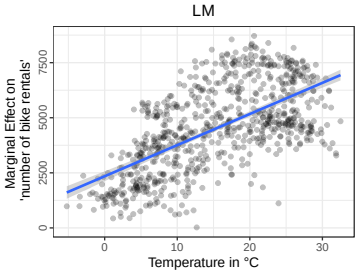
Feature Effects
Introduction

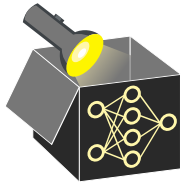


Learning goals

- Global Feature Effects
- Local Feature Effects

FEATURE EFFECTS - GLOBAL VIEW

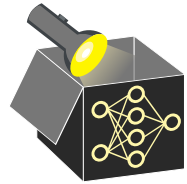


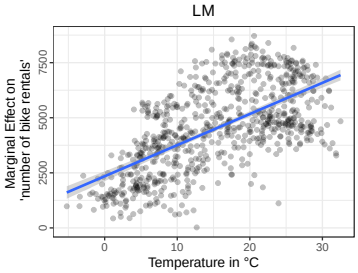


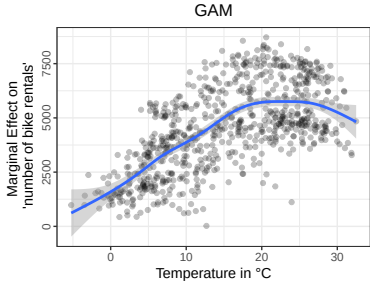
LM without interaction:
$\hat{\theta}_j$ is linear effect of feature x_j
(applies globally to all observations):

- Model equation: $\hat{f}(\mathbf{x}) = \hat{\theta}_0 + x_1\hat{\theta}_1$
- Scalar $\hat{\theta}_1$ describes global effect

FEATURE EFFECTS - GLOBAL VIEW







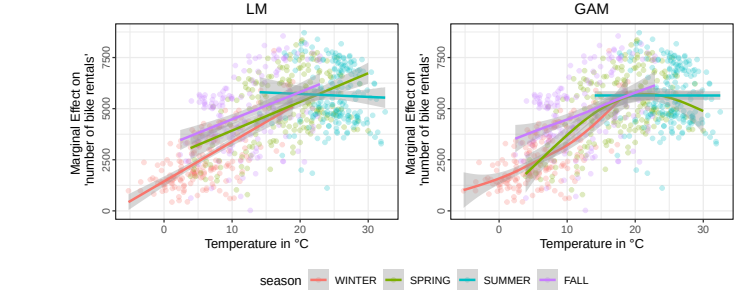
LM without interaction:
$\hat{\theta}_j$ is linear effect of feature x_j
(applies globally to all observations):

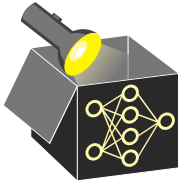
- Model equation: $\hat{f}(\mathbf{x}) = \hat{\theta}_0 + x_1\hat{\theta}_1$
- Scalar $\hat{\theta}_1$ describes global effect

GAM without interaction:
$\hat{f}_j(x_j)$ is non-lin. effect of feature x_j
(applies globally to all observations):

- Model equation: $\hat{f}(\mathbf{x}) = \hat{\theta}_0 + \hat{f}_1(x_1)$
- Curve $\hat{f}_1$ describes global effect

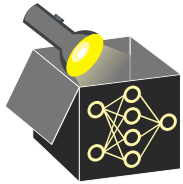
FEATURE EFFECTS - LOCALIZED VIEW





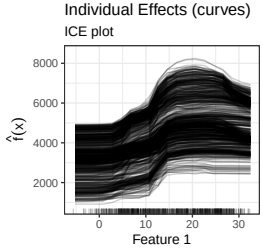
- **Interactions:** Feature effect depends on other features and varies across obs.
  ⇒ E.g., effect of **temperature** varies across **season**
  ⇒ Multiple values / curves needed to describe effect
- ML models capture non-linear effects and high-order interactions
  ⇒ Global view may mislead (single curve may fail to capture complexity)
  ⇒ Local feat. effect methods needed to estimate effects for individ. obs.
  ⇒ Global view can be reconstructed by aggregating local effects

FEATURE EFFECTS



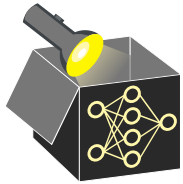
Feature effects visualize or quantify how model predictions change as a single feature varies, while all other features are held fixed.

- Analogous to regression coefficients (LMs) or Splines (GAMs)
- Different aggregation levels exist (simplification but information loss)
- Methods: ICE curves (local curves)



Individual (curves)

FEATURE EFFECTS



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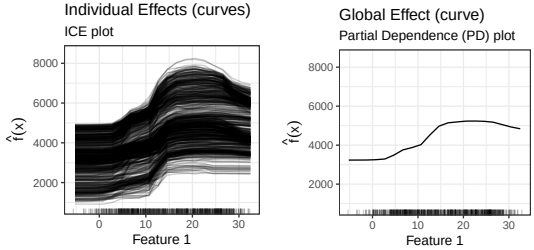
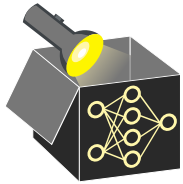
- Methods: ICE curves (local curves), PD and ALE plots (global curves)



Individual (curves) $\xrightarrow[\text{curves}]{\text{aggregate}}$ Global (single curve)

FEATURE EFFECTS



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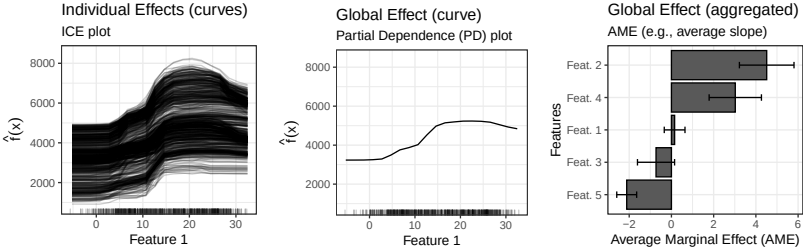
- Analogous to regression coefficients (LMs) or Splines (GAMs)
- Different aggregation levels exist (simplification but information loss)
- Methods: ICE curves (local curves), PD and ALE plots (global curves), AME (global value)



Individual (curves) $\xrightarrow[\text{curves}]{\text{aggregate}}$ Global (single curve) $\xrightarrow[\text{slopes}]{\text{aggregate}}$ Global (single value)