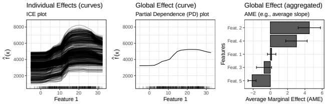
Interpretable Machine Learning

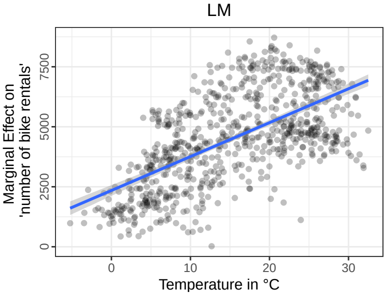
Introduction to Feature Effects



Learning goals

- Global Feature Effects
- Local Feature Effects

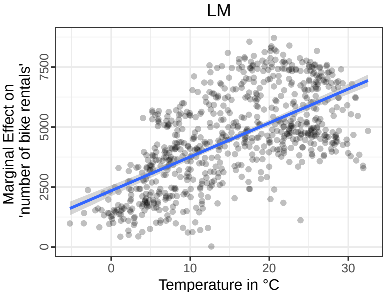
FEATURE EFFECTS - GLOBAL VIEW

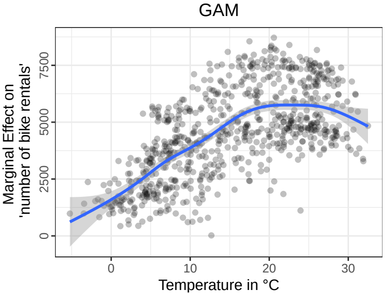


LM without interaction: $\hat{\theta}_j$ is linear effect of feature x_j (applies globally to all observations):

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

FEATURE EFFECTS - GLOBAL VIEW





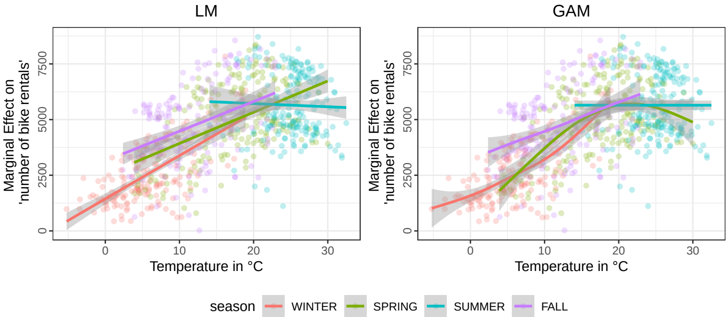
LM without interaction: $\hat{\theta}_j$ is linear effect of feature x_j (applies globally to all observations):

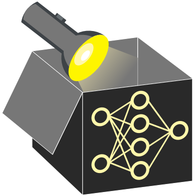
- Model equation: $\hat{f}(\mathbf{x}) = \hat{\theta}_0 + x_1\hat{\theta}_1$
- Single value $\hat{\theta}_1$ describes global effect

GAM without interaction: $\hat{f}_j(x_j)$ is non-linear effect of feature x_j (applies globally):

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

FEATURE EFFECTS - LOCAL VIEW



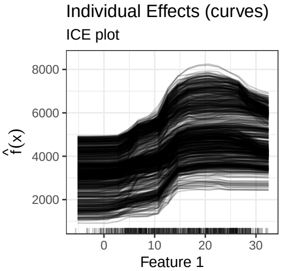


- Interactions: Feature effect is modified by other features and varies across observations
  ⇒ Effect of temperature varies across seasons
  ⇒ Multiple values / curves needed to describe effect
- ML models often model non-linear effects and complex interactions
  ⇒ Need for local feature effect methods, e.g., analyze effect for individual observations
  ⇒ Analyzing global effects by aggregating local effects

FEATURE EFFECTS

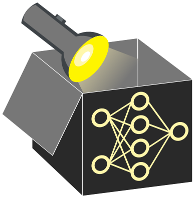
Feature effects visualize or quantify marginal contribution of a feature of interest w.r.t. predictions

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



Individual (curves)

FEATURE EFFECTS



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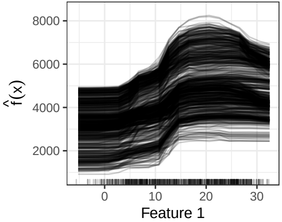
- Different aggregation levels for feature effects exist (simplification but information loss)
- Methods: ICE curves (local curves), PD and ALE plots (global curves)

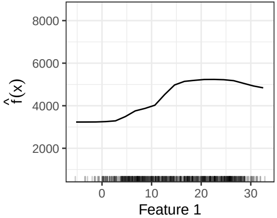
Individual Effects (curves)

ICE plot



Global Effect (curve)

Partial Dependence (PD) plot



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

FEATURE EFFECTS

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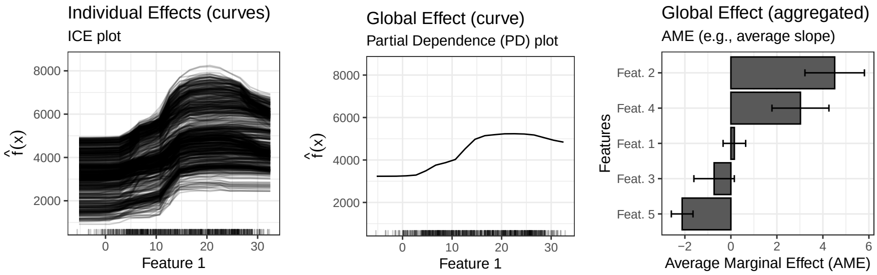
- Methods: ICE curves (local curves), PD and ALE plots (global curves), AME (global value)



Individual Effects (curves)

ICE plot

Global Effect (curve)

Partial Dependence (PD) plot

Global Effect (aggregated)

AME (e.g., average slope)

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