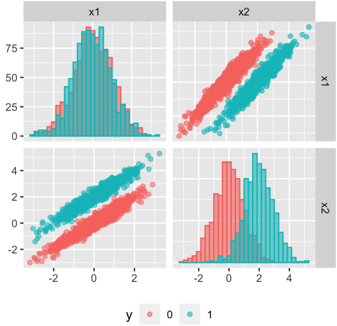
Introduction to Machine Learning

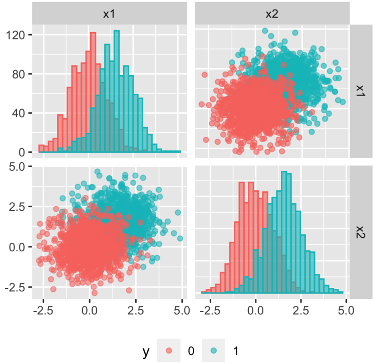
Feature Selection
Feature Selection: Filter Methods (Examples and Caveats)

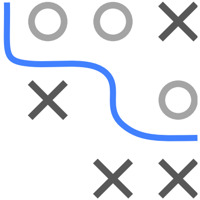


Learning goals

- Understand how filter methods can be misleading
- Understand how filters can be applied and tuned

FILTER METHODS CAN BE MISLEADING



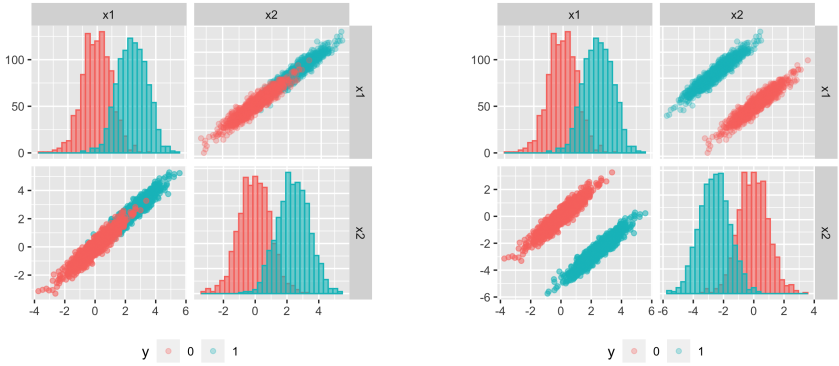


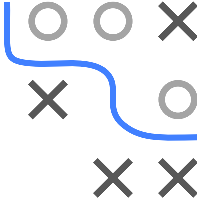
ρ_{ACC} of log. reg. classifier with:

- feature x_1: 0.76
- feature x_2: 0.78
- both features: 0.85

Information gain from presumably redundant variables. 2 class problem with indep features. Each class has Gaussian distribution with no covariance. While filter methods suggest redundancy, combination of both vars yields improvement, showing indep vars are not truly redundant. For further details, see ▸ Guyon and Elisseeff 2003.

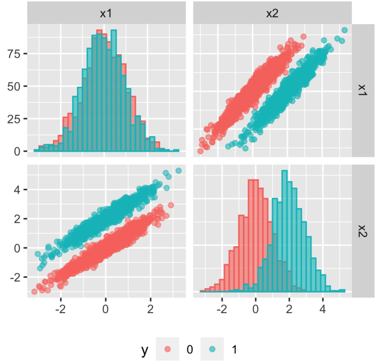
FILTER METHODS CAN BE MISLEADING / 2

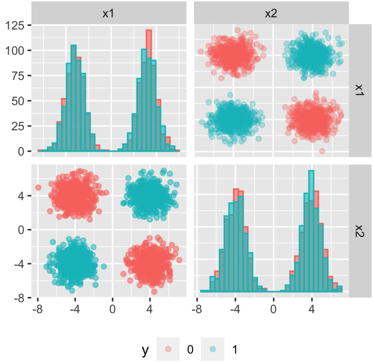


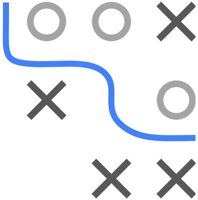


Intra-class covariance. In projection onto axes, distr. of two variables are same as before. Left: Class conditional distr. have high cov. in direction of the line of two class centers. Right: Class conditional distr. have high cov. in direction perpendicular to line of two class centers. Better separation by using both vars.

FILTER METHODS CAN BE MISLEADING / 3



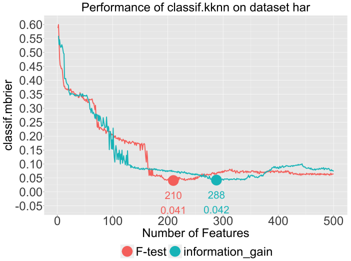




Variable useless by itself can be useful together with others. Left: One var has completely overlapping class conditional densities. Still, jointly with other variable separability can be improved. Right: XOR-like chessboard problem. Classes consist of “clumps" s.t. projection on the axes yields overlapping densities. Single vars have no separation power, only used together.

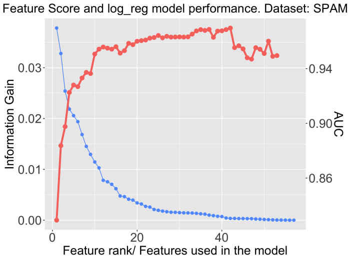
USING FILTER METHODS

1. Calculate filter score for each feature x_j
2. Rank features according to score values
3. Choose $\tilde{p}$ best features
4. Train model on $\tilde{p}$ best features

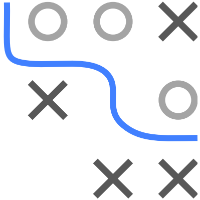


How to choose $\tilde{p}$?

- Could be prescribed by application
- Eyeball estimation: read from filter plots
- Treat as hyperparameter and tune in a pipeline, based on resampling



USING FILTER METHODS / 2



Advantages:

- Easy to calculate
- Typically scales well with the number of features p
- Generally interpretable
- Model-agnostic

Disadvantages:

- Univariate analyses may ignore multivariate dependencies
- Redundant features will have similar weights
- Ignores the learning algorithm